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for
Effluent Limitations Guidelines and Standards
for the
COIL COATING
POINT SOURCE CATEGORY

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SECTION I

SUMMARY AND CONCLUSIONS

Pursuant to Sections 301, 304, 306, 307, and 501 of the Clean Water Act, EPA has collected and analyzed data for plants in the Coil Coating Point Source Category. Effluent limitations and performance standards for this industry were proposed on January 12, 1981 (46 FR 2934). This document and the administrative record provide the technical basis for promulgating effluent limitations for existing direct dischargers, standards for new source direct dischargers, and pretreatment standards for new and existing indirect dischargers.

Industry Description

"Coil coating" is a term generally used to describe the combination of processing steps involved in converting a coil - a long thin strip of metal rolled into a coil - into a coil of painted metal ready for further industrial use. Three basis materials are commonly used for coil coating: steel, galvanized (steel), and aluminum.

EPA estimates that there are more than 69 coil coating plants in the United States, operating over 125 coil coating lines.

There are three major groups or standard process steps used in manufacturing coated coils: (1) cleaning to remove soil, oil, corrosion, and similar dirt; (2) chemical conversion coating in which a coating of chromate, phosphate or complex oxide materials is chemically formed in the surface of the metal; and (3) the application and drying of one or more coats of organic polymeric material such as paint.

The cleaning processes for removing oil and dirt usually employ water-based alkaline cleaners, and acid pickling solutions are sometimes used to remove oxides and corrosion. Water is used to rinse the strip after it has been cleaned. Most of the chemical conversion coating processes are water based and water is used to rinse excess and spent solutions from the strip. After painting, the strip is baked in an oven to dry the paint and then chilled with water to prevent burning or charring of the organic coating.

The most important resulting pollutants or pollutant parameters are: (1) toxic pollutants - chromium, zinc, nickel, lead, copper, cyanide; (2) conventional pollutants - suspended solids, pH, and oil and grease, and (3) nonconventional pollutants - iron, aluminum, phosphorous, and fluoride. Toxic organic pollutants were not found in large quantities.

In developing this regulation, EPA studied the coil coating category to determine whether differences in raw materials, final products, manufacturing processes, equipment, age and size of plants, water use, wastewater constituents, or other factors required the development of separate effluent limitations and standards for different segments (or subcategories) of the industry.

EPA has subcategorized the coil coating industry based on the basis material coated. The subcategories are defined as coil coating on: (1) steel, (2) galvanized (zinc-coated steel either hot dipper or electrolytically coated), and (3) aluminum (including aluminum coated steel). The galvanized subcategory includes copper, (including copper alloys such as brass) and galvalum, a zinc-aluminum alloy. The steel subcategory includes chromium, nickel and tin-coated steels.

This study included the identification of raw waste and treated effluent characteristics, including the sources and volume of water used, the processes employed, and the sources of pollutants and wastewaters. Such analysis enabled EPA to determine the presence and concentration of priority pollutants in wastewater discharges.

EPA also identified both actual and potential control and treatment technologies (including both in-plant and end-of-process technologies). The Agency analyzed both historical and newly generated data on the performance of these technologies, including the performance, operational limitations, and reliability.

Wastewater treatment practices in the coil coating category range from no treatment to a high level of physical chemical treatment combined with water conservation practices. Of the 69 plants for which data is available, about 15 percent of the plants employ no treatment 71 percent employ some form of chemical reduction, 59 percent have sedimentation or clarification devices, 54 percent have alkaline pH adjust systems, and 35 percent have acid pH adjust systems. There is no apparent difference between direct or indirect dischargers in the nature of degree of treatment employed.

The control and treatment technologies available for this category include both in-process and end-of-pipe treatments. In-process treatment includes a variety of water flow reduction steps and major process changessuch as: cascade rinsing to reduce the amount of water used in removing unwanted materials from the product surface; cooling and recycling of quench water; and substitution of non-wastewater generating conversion coating processes. End-of-pipe treatment includes: cyanide oxidation or precipitation; hexavalent chromium reduction; chemical precipitation of metals using hydroxides, carbonates, or sulfites; and removal of precipitated metals and other materials using settling, sedimentation, filtration, and combinations of these technologies.

The effectiveness of these treatment technologies has been evaluated and established by examining the performance of these technologies on coil coating and other similar wastewaters. The data base for hydroxide precipitation sedimentation technology is a composite of data drawn from EPA sampling and analysis of aluminum forming, coil coating, copper forming, battery manufacturing, and porcelain enameling. These wastewaters are judged to be similar in all material respects for treatment because they contain a range of dissolved metals which can be removed by precipitation and solids removal. This judgment has been confirmed by statistical analyses of the treatment effectiveness data. Similarly precipitation sedimentation and filtration (lime, settle and filter) technology performance is based on the performance of full scale commercial systems treating wastewaters which also are essential similar to coil coating wastewaters.

The Agency then estimated the costs of each control and treatment technology using a computer program developed using standard engineering cost analysis. EPA derived unit process costs for each of 58 plants using data and characteristics (production and flow) applied to each treatment process (i.e., hexavalent chromium reduction, metals precipitation, sedimentation, multi-media filtration, etc.). These unit process costs were added to yield total cost at each treatment level. After confirming the reasonableness of this methodology by comparing EPA cost estimates to treatment system costs supplied by industry, the Agency evaluated the economic impacts of these costs.

On the basis of these factors, EPA identified various control and treatment technologies as BPT, BAT, NSPS, PSES and PSNS. The regulation, however, does not require the installation of any particular technology. Rather, it requires achievement of effluent limitations equivalent to those achieved by the proper operation of these or equivalent technologies.

Except for pH requirements, the effluent limitations for BPT, BAT, NSPS, PSES and PSNS are expressed as mass limitations or standards - a mass of pollutant per unit of production (mg/m^2). They are calculated by combining three factors: (1) Treated effluent concentrations determined from analysis of control technology performance data; (2) wastewater flow for each subcategory; and (3) relevant process or treatment variability factors (E.G. mean vs. maximum day).

Because flow reduction is a significant pollutant reduction technology for this category, mass based limitations and standards are necessary to ensure application and implementation of the model or equivalent technology.

BPT - BPT represents the average of the best existing performances of plants of various ages, sizes, processes or other common characteristics. Where existing performance is uniformly inadequate, BPT may be transferred from a different subcategory or category. In selecting BPT model technology, EPA considered the volume and nature of existing discharges, the volume and nature of discharges expected after application of BPT, the general environmental effects of the pollutants, and the cost and economic impacts of the required pollution control level.

This regulation imposes BPT requirements on all three subcategories. The technology basis for the BPT limitations being promulgated is the same as for the proposed regulation and includes removal of cyanide and reduction of hexavalent chromium in conversion coating wastewaters; combination of all wastewater streams and oil skimming to remove oil and grease and some organics; and lime and settle technology to remove metals and solids from the combined wastewaters. Sludge from the settling tank is concentrated to facilitate landfill disposal. The effluent which would be expected to result from the application of these technologies was evaluated against the known performance of some of the best plants in the category. From this examination, the Agency found that there is uniformly inadequate performance due to improper operating practices throughout the category. The basis for this finding is detailed in Sections VII and IX of this document.

The pollutants regulated in all three subcategories under BPT include chromium, cyanide, zinc, oil and grease, TSS and pH. Additionally, iron is regulated in the steel subcategory, iron and copper are regulated in the galvanized subcategory and aluminum is regulated in the aluminum subcategory.

The BPT technology outlined above applies to all of the coil coating subcategories and the final effluent concentrations resultinf from the application of the technology are identical for all three subcategories. However, the mass limitations for each subcategory vary due to different water uses among the subcategories and the absence of some pollutants in some subcategories.

Implementation of the BPT limitations will remove annually an estimated 113,100 kg of toxic pollutants and 775,700 kg of other pollutants at a capital cost above equipment already in place of $6.98 million and an annual cost of $2.72 million.

BAT - The BAT technology level represents the best economically achievable performance of plants of various ages, sizes, processes or other shared characteristics. As with BPT, where existing performance is uniformly inadequate, BAT may be transferred from a different subcategory or category. BAT may include feasible process changes or internal controls, even when not common industry practice.

In developing BAT, EPA gave substantial weight to the reasonableness of costs. The Agency considered the volume and nature of discharges, the volume and nature of discharges expected after application of BAT, the general environmental effects of the pollutants, and the costs and economic impacts of the required pollution control levels.

Despite this consideration of costs, the primary determinant of BAT is effluent reduction capability.

This regulation establishes BAT for all three subcategories. The BAT limitatiins being promulgated are changed from the proposed BAT limitations. The promulgated BAT limitations are based on the technology for BPT plus in-process wastewater reduction including quench water recycle and reuse. The proposed BAT limitations were based on the BPT technology plus filtration after sedimentation and in-process wastewater reduction. Industry objected to the use of filtration because of its cost. The incremental effluent reduction benefits of the proposed BAT above the promulgated BAT are the removal annually of 150 kg of toxic pollutants and 9,790 kg of other pollutants. The incremental costs of these benefits are $1.48 million capital cost and $1.25 million total annual costs. In response to these comments the Agency re-evaluated filtration and determined that filtration was too costly for existing facilities.

The pollutants regulated under BAT are chromium, copper, cyanide, zinc, aluminum and iron.

Implementation of the BAT Limitations will remove annually an estimated 113,800 kg of toxic pollutant and 827,700 kg of other pollutants at a capital cost above equipment in place of $6.91 million and an annual cost of $2.64 million.

NSPS - NSPS are based on the best available demonstrated technology (BDT). New plants have the opportunity to install the best and most efficient production processes and wastewater treatment technologies rather than be constrained by existing equipment, buildings or locations. EPA considered three options before selection of NSPS technology at proposal. After public comments were received the proposed NSPS technology was modified. The technology basis for the NSPS being promulgated includes recycle of quench water, reuse of quench water blowdown as cleaning and conversion coating rinse water with three stage countercurrent cascade rinsing for both cleaning and conversion coating, cyanide removal, chromium reduction, oil skimming, lime, settle and filter metals removal and dewatering of sludge.

The Agency proposed no rinse conversion coatings as a part of the basis for the proposed NSPS. However, the industry commented that no rinse conversion coating has not been demonstrated for some applications and there is no Food and Drug Administration approved no rinse conversion coating. Since food containers are often manufactured from coil coated stock, it is necessary to have FDA approval of the coating applied to the coil. The Agency reconsidered the requirement for no rinse conversion coating and substituted multistage countercurrent cascade rinsing in both the cleaning and conversion coating segments. The pollutants regulated under NSPS are the same as those under BPT.

A new direct discharge normal plant having the industry average annual production level in the steel subcategory, would generate a raw waste of 548 kg/yr toxic pollutants and 18,400 kg/yr total pollutants. The NSPS technology would reduce these pollutants levels to 4 kg/yr toxics and 60 kg/yr total pollutants.

PSES - PSES are designed to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of publicly owned treatment works (POTW). Pretreatment standards for existing sources are to be technology-based, analogous to the best available technology for removal of toxic pollutants.

The pollutants to be regulated by PSES Include chromium, copper, cyanide, and zinc. Oil and grease and TSS are not regulated by pretreatment because these conventional plllutants in the quantities encountered do not interfere with or pass through a POTW. Iron and aluminum, which are sometimes added as coagulant aids at POTW are not regulated by pretreatment because at the levels released to the POTW, they will neither pass through nor interfere with the POTW.

The technology basis for PSES is analogous to BAT; flow reduction by reusing quench water, hexavalent chromium reduction, cyanide removal, and lime and settle end-of-pipe treatment. The Agency proposed PSES based in part on filtration after lime and settle treatment. The Agency proposed PSES based in part on filtration after lime and settle treatment. Because, as indicated above in the BAT discussion, filters were found to be too costly for existing facilities they are not included in the technology basis for PSES. The remainder of the BAT technology outlined above applies.

Implementation of the PSES standards will remove annually an estimated 165,000 kg of toxic pollutants and 1,203,600 kg of other pollutants at a capital cost above equipment in place of $10.29 million and an annual cost of $3.37 million.

PSNS - Like PSES, PSNS are to prevent the discharge of pollutants which pass through, interfere with,pass through, interfere with, or are otherwise incompatible with the operation of the POTW. New indirect dischargers, like new direct dischargers, have the opportunity to incorporate the best available demonstrated technologies.

The technology used as a basis for proposing and now promulgating PSNS is analogous to the technologies for proposing and promulgating NSPS except that oil skimming is not required. The changes from proposal technology to promulgation technology are discussed under NSPS above and apply equally to PSNS. The pollutants regulated under PSNS are chromium, copper, cyanide and zinc for the reasons cited under PSES.

Non-Water Quality Environmental Impacts - Eliminating or reducing one form of pollution may cause other environmental problems. Sections 304(b) and 306 of the Act require EPA to consider the non-water quality environmental impacts (including energy requirements) of certain regulations. In compliance with these provisions, we considered the effect of this regulation on air pollution, solid waste generation, radiation and energy consumption. While it is difficult to balance pollution problems against each other and against energy use, we believe that this regulation will best serve often competing national goals.

Only one of the wastewater treatment sludges from coil coating is likely to be hazardous under the regulations implementing subtitle C of the Resource Conservation and Recovery Act (RCRA). Under those regulations, generators of these wastes must test the wastes to determine if the wastes meet any of the characteristics of hazardous waste (see 40 CFR 8262.11, 45 FR 33142-33143, May 19, 1980). Wastewater sludge generated by aluminum coil coating may contain cyanides and may exhibit extraction procedure (EP) toxicity. Therefore these wastes may require disposal as a hazardous waste. The estimated added cost above the cost of disposing an equivalent mass of non-hazardous waste is $361,800 per year.

To achieve the BPT and BAT effluent limitations, a typical direct discharger will increase total energy consumption by less than one percent of the energy consumed for production purposes.

SECTION II

RECOMMENDATIONS

1. EPA has divided the coil coating category into three subcategories for the purpose of effluent limitations and standards. These subcategories are:

steel
galvanized
aluminum

2. The following effluent limitations are promulgated for existing sources:

A. Subcategory A - Steel Basis Material

(a) BPT Limitations

Pollutant or Pollutant Property	BPT Effluent Limitations Maximum for any one day	BPT Effluent Limitations Maximum for monthly average
	mg/m² (lb/1,000,000 ft²) of area processed	
Chromium	1.16 (0.24)	0.47 (0.096)
Cyanide	0.80 (0.17)	0.33 (0.068)
Zinc	3.66 (0.75)	1.54 (0.32)
Iron	3.39 (0.70)	1.74 (0.36)
Oil and Grease	55.1 (11.3)	33.1 (6.77)
TSS	113. (23.1)	55.1 (11.3)
pH	Within the range of 7.5 to 10.0 at all times.	

(b) BAT Limitations

Pollutant or Pollutant Property	BAT Effluent Limitations Maximum for any one day	BAT Effluent Limitations Maximum for monthly average
	mg/m² (lb/1,000,000 ft²) of area processed	
Chromium	0.50 (0.10)	0.20 (0.041)
Cyanide	0.34 (0.07)	0.14 (0.029)
Zinc	1.56 (0.32)	0.66 (0.14)
Iron	1.45 (0.30)	0.74 (0.15)

B. Subcategory B - Galvanized Basis Material

(a) BPT Limitations

Pollutant or Pollutant Property	BPT Effluent Limitations Maximum for any one day		Maximum for monthly average	
	mg/m^2 (lb/1,000,000 ft^2) of area processed			
Chromium	1.10	(0.23)	0.45	(0.091)
Copper	4.96	(1.02)	2.61	(0.54)
Cyanide	0.76	(0.16)	0.32	(0.064)
Zinc	3.47	(0.71)	1.46	(0.30)
Iron	3.21	(0.66)	1.65	(0.34)
Oil and Grease	52.2	(10.7)	31.3	(6.42)
TSS	107	(21.9)	52.2	(10.7)
pH	Within the range of 7.5 to 10.0 at all times.			

(b) BAT Limitations

Pollutant or Pollutant Property	BAT Effluent Limitations Maximum for any one day		Maximum for monthly average	
	mg/m^2 (lb/1,000,000 ft^2) of area processed			
Chromium	0.37	(0.077)	0.16	(0.031)
Copper	1.71	(0.35)	0.90	(0.19)
Cyanide	0.26	(0.053)	0.11	(0.022)
Zinc	1.20	(0.25)	0.51	(0.11)
Iron	1.10	(0.23)	0.57	(0.12)

C. Subcategory C - Aluminum Basis Material

(a) BPT Limitations

Pollutant or Pollutant Property	BPT Effluent Limitations			
	Maximum for any one day		Maximum for monthly average	
	mg/m^2 (lb/1,000,000 ft^2) of area processed			
Chromium	1.42	(0.29)	0.58	(0.12)
Cyanide	0.98	(0.20)	0.41	(0.083)
Zinc	4.48	(0.92)	1.89	(0.39)
Aluminum	15.3	(3.14)	6.26	(1.28)
Oil and Grease	67.3	(13.8)	40.4	(8.27)
TSS	138.	(28.3)	67.3	(13.8)
pH	Within the range of 7.5 to 10.0 at all times.			

(b) BAT Limitations

Pollutant or Pollutant Property	BAT Effluent Limitations			
	Maximum for any one day		Maximum for monthly average	
	mg/m^2 (lb/1,000,000 ft^2) of area processed			
Chromium	0.42	(0.085)	0.17	(0.034)
Cyanide	0.29	(0.059)	0.12	(0.024)
Zinc	1.32	(0.27)	0.56	(0.12)
Aluminum	4.49	(0.92)	1.84	(0.38)

3. The following effluent standards are being proposed for new sources.

A. Subcategory A - Steel Basis Material

Pollutant or Pollutant Property	NSPS			
	Maximum for any one day		Maximum for monthly average	
	mg/m^2 (lb/1,000,000 ft^2) of area processed			
Chromium	0.12	(0.024)	0.047	(0.01)
Cyanide	0.063	(0.013)	0.025	(0.005)
Zinc	0.33	(0.066)	0.14	(0.027)
Iron	0.39	(0.086)	0.20	(0.041)
Oil and Grease	3.16	(0.65)	3.16	(0.65)
TSS	4.74	(0.97)	3.48	(0.72)
pH	Within the range of 7.5 to 10.0 at all times.			

B. Subcategory B - Galvanized Basis Material

Pollutant or Pollutant Property	NSPS Maximum for any one day		NSPS Maximum for monthly average	
	mg/m² (lb/1,000,000 ft²) of area processed			
Chromium	0.13	(0.027)	0.052	(0.011)
Copper	0.44	(0.090)	0.21	(0.043)
Cyanide	0.07	(0.015)	0.028	(0.006)
Zinc	0.35	(0.08)	0.15	(0.030)
Iron	0.43	(0.09)	0.22	(0.045)
Oil and Grease	3.43	(0.71)	3.43	(0.702)
TSS	5.15	(1.06)	3.78	(0.78)
pH	Within the range of 7.5 to 10.0 at all times.			

C. Subcategory C - Aluminum Basis Material

Pollutant or Pollutant Property	NSPS Maximum for any one day		NSPS Maximum for monthly average	
	mg/m² (lb/1,000,000 ft²) of area processed			
Chromium	0.18	(0.037)	0.072	(0.015)
Cyanide	0.095	(0.020)	0.038	(0.008)
Zinc	0.49	(0.10)	0.20	(0.041)
Aluminum	1.44	(0.30)	0.59	(0.121)
Oil and Grease	4.75	(0.98)	4.75	(0.98)
TSS	7.13	(1.46)	5.23	(1.07)
pH	Within the range of 7.5 to 10.0 at all times.			

4. The following pretreatment standards are promulgated for existing sources and new sources.

A. Subcategory A - Steel Basis Material

(a) Pretreatment Standards for Existing Source

Pollutant or Pollutant Property	PSES			
	Maximum for any one day		Maximum for monthly average	
	mg/m^2 (lb/1,000,000 ft^2) of area processed			
Chromium	0.50	(0.10)	0.20	(0.041)
Cyanide	0.34	(0.07)	0.14	(0.029)
Zinc	1.56	(0.32)	0.66	(0.14)

(b) Pretreatment Standards for New Source

Pollutant or Pollutant Property	PSNS			
	Maximum for any one day		Maximum for monthly average	
	mg/m^2 (lb/1,000,000 ft^2) of area processe			
Chromium	0.12	(0.024)	0.047	(0.01)
Cyanide	0.063	(0.013)	0.025	(0.005)
Zinc	0.33	(0.066)	0.14	(0.027)

B. Subcategory B - Galvanized Basis Material

(a) Pretreatment Standards for Existing Source

Pollutant or Pollutant Property	PSES			
	Maximum for any one day		Maximum for monthly average	
	mg/m^2 (lb/1,000,000 ft^2) of area processed			
Chromium	0.37	(0.077)	0.16	(0.031)
Copper	1.71	(0.35)	0.90	(0.19)
Cyanide	0.26	(0.053)	0.11	(0.022)
Zinc	1.20	(0.25)	0.51	(0.11)

(b) Pretreatment Standards for New Source

Pollutant or Pollutant Property	PSNS			
	Maximum for any one day		Maximum for monthly average	
	mg/m² (lb/1,000,000 ft²) of area processed			
Chromium	0.13	(0.027)	0.052	(0.011)
Copper	0.44	(0.090)	0.21	(0.043)
Cyanide	0.07	(0.015)	0.028	(0.006)
Zinc	0.35	(0.072)	0.15	(0.030)

C. Subcategory C - Aluminum Basis Material

(a) Pretreatment Standards for Existing Source

Pollutant or Pollutant Property	PSES			
	Maximum for any one day		Maximum for monthly average	
	mg/m² (lb/1,000,000 ft²) of area processed			
Chromium	0.42	(0.085)	0.17	(0.34)
Cyanide	0.29	(0.059)	0.12	(0.024)
Zinc	1.32	(0.27)	0.56	(0.12)

(b) Pretreatment Standards for New Source

Pollutant or Pollutant Property	PSNS			
	Maximum for any one day		Maximum for monthly average	
	mg/m² (lb/1,000,000 ft²) of area processed			
Chromium	0.18	(0.037)	0.072	(0.015)
Cyanide	0.095	(0.02)	0.038	(0.008)
Zinc	0.049	(0.01)	0.20	(0.041)

5. Effluent limitations based on the best conventional treatment are reserved.

SECTION III

INTRODUCTION

LEGAL AUTHORITY

Pollution The Federal Water Pollution Control Act Amendments of 1972 established a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (Section 101(a)). To implement the Act, EPA was to issue effluent limitations, pretreatment standards, and new source performance standards for industry dischargers.

The Act included a timetable for issuing these standards. However, EPA was unable to meet many of the deadlines and, as a result, in 1976, it was sued by several environmental groups. In settling this lawsuit, EPA and the plaintiffs executed a court-approved "Settlement Agreement." This Agreement required EPA to develop a program and adhere to a schedule in promulgating effluent limitations guidelines, new source performance standards and pretreatment standards for 65 "priority" pollutants and classes of pollutants, for 21 major industries. See Natural Resources Defense Council, Inc. v. Train, 8 ERC 2120 (D.D.C. 1976), modified, 12 ERC 1833 (D.D.C. 1979).

Many of the basic elements of this Settlement Agreement program were incorporated into the Clean Water Act of 1977. Like the Agreement, the Act stressed control of toxic pollutants, including the 65 "priority" pollutants. In addition, to strengthening the toxic control program, Section 304(e) of the Act authorizes the Administrator to prescribe "best management practices" (BMP) to prevent the release of toxic and hazardous pollutants from plant site runoff, spillage or leaks, sludge or waste disposal, and drainage from raw material storage associated with, or ancillary to, the manufacturing or treatment process.

GUIDELINES DEVELOPMENT SUMMARY

These effluent limitations and standards were developed from data obtained from previous EPA studies, literature searches, and a plant survey and evaluation program. This program was carried out in 1978-79 and detailed the category based primarily on 1977 data. This information was then catalogued in the form of individual plant summaries describing processes performed, production rates, raw materials utilized, wastewater treatment practices, water uses and wastewater characteristics.

In addition to providing a quantitative description of the coil coating category, this information was used to determine if the characteristics of the category as a whole were uniform and thus amenable to one set of effluent limitations and standards. Since the characteristics of the plants in the data base and the wastewater generation and discharge varied widely, the establishment of subcategories was determined to be necessary. The initial subcategorization of the category was made by using basis material processed as the subcategory descriptor. The subcategorization process is discussed fully in Section IV. To supplement existing data, the Agency sent a data collection portfolio (dcp) under authority of Section 308 of the Federal Water Pollution Control Act, as amended, to each known coil coating company. Additional data were obtained through a sampling program carried out at selected sites. Sampling consisted of a screening program at one plant for each listed basis material type, plus verification at up to 5 plants for each type. Screen sampling was utilized to select pollutant parameters for analysis in the second (verification) phase of the program. The designated priority pollutants (65 toxic pollutants) and typical coil coating pollutants formed the basic list for screening. Verification sampling and analysis was conducted to determine the source and quantity of the selected pollutant parameters in each subcategory.

After establishing subcategorization, EPA analyzed the available data to determine wastewater generation and mass discharge rates in terms of production for each basis material subcategory. In addition to evaluating pollutant generation and discharges, the Agency identified the full range of control and treatment technologies existing within the coil coating category. This was done considering the pollutants to be treated and the chemical, physical and biological characteristics of these pollutants. Special attention was paid to in-process technology such as the recovery and reuse of process solutions, the recycle of process water and the curtailment of water use.

Consideration of these factors enabled EPA to characterize various levels of technology as the basis for effluent limitations for existing sources based on BPT and BAT. Levels of technology appropriate for pretreatment of wastewater introduced into a POTW from both new and existing sources were also identified, as were the NSPS based on best demonstrated control technology processes, operating methods, or other alternatives (BDT) for the control of direct discharges from new sources. These technologies were considered in terms of demonstrated effluent performance relative to treatment technologies, pretreatment requirements, the total cost of application of the technology in relation to the effluent reduction benefits to be achieved, the age of equipment and facilities involved, the processes employed, the engineering aspects of applying various types of control technique process changes, and non-water quality environmental impacts (including energy requirements).

Sources of Industry Data

Data on the coil coating category were gathered from previous EPA studies, literature studies, inquiries to federal and state environmental agencies, raw material manufacturers and suppliers, trade association contacts and the coil coating manufacturers themselves. Additionally, meetings were held with industry representatives and the EPA. All known coil coaters were sent a data collection portfolio (dcp) requesting specific information concerning each facility. Finally, a sampling program was carried out at 13 plants. The sampling program consisted of screen sampling and analysis at three facilities to determine the presence of a broad range of polluants and verificiation at 13 plants to quantify the pollutants present in coil coating wastewater. Specific details of the sampling program and information from the above data sources are presented in Section V.

The coil coating manufactures submitted information as public comments on the proposed document. The Agency considered public comments in preparing the final regulation.

Literature Study - Published literature in the form of books, reports, papers, periodicals, and promotional materials was examined. The most informative sources are listed in Section XV.

EPA Studies - A previous preliminary and unpublished EPA study of the coil coating segment was reviewed. This study summarized the industry describing: the manufacturing processes; the associated waste characteristics; recommended pollutant parameters requiring control; applicable end-of-pipe treatment technologies for wastewaters; effluent characteristics resulting from this treatment; and a background bibliography. Also included in these data were detailed production and sampling information on approximately 26 manufacturing plants.

Plant Survey and Evaluation - The collection of data pertaining to coil coating facilities was a two-phased operation. First, EPA mailed a dcp to each company in the country known or believed to perform coil coating. This dcp included sections for general plant data, specific production process data, waste management process data, raw and treated wastewater data, wastewater treatment cost information, and priority pollutant information based on 1976 production records. A total of 68 requests for information were mailed. From this mailing, it was determined that 52 companies were coil coaters. Of the remaining 16 data requests, 1 company was no longer doing coil coating, and 15 were in other business areas. The 52 companies operate 69 coil coating plants with 125 coil coating lines. Some plants responded with 1977 or 1978 data, while most provided 1976 data. Since proposal, the Agency has collected new data and information from one additional plant.

Utilization of Industry Data

Data collected from the previously listed sources are used throughout this report in the development of a base for BPT and BAT limitations and NSPS and pretreatment standards. Previous EPA studies as well as the literature provided the basis for the coil coating subcategorization discussed in Section IV. Raw wastewater characteristics for each subcategory presented in Section V were obtained from the screening and verification sampling. Dcp information on wastewater characteristics was incomplete. Selection of pollutant parameters for control (Section VI) was based on both dcp responses and verification and screening results. These provided information on both the pollutants which the plant personnel felt were in their wastewater discharges and those pollutants specifically found in coil coating wastewaters as the result of sampling. Based on the selection of pollutants requiring control and their levels, applicable treatment technologies were identified and described in Section VII of this document. Actual wastewater treatment technologies utilized by coil coating plants (as identified in the dcp responses and observed at the sampled plants) were also used to identify applicable treatment technologies. The cost of treatment (both individual technologies and systems) were based primarily on data from equipment manufacturers and are contained in Section VIII of this document. Finally, dcp data, sampling data and estimated treatment system performance are utilized in Sections IX, X, XI and XII (BPT, BAT, NSPS and pretreatment, respectively) in the selection of applicable treatment systems; the presentation of achievable effluent levels; and the presentation of actual effluent levels obtained for each coil coating subcategory.

After proposal wastewater flow data, treatment effectiveness data (the combined data base) and the cost basis for treatment costs were reanalyzed. These reanalyses are discussed in detail in the appropriate sections.

DESCRIPTION OF THE COIL COATING INDUSTRIAL SEGMENT

Background

The category covered by this document consists of facilities which clean, chemically treat and paint continuous (long) strips of metal called coils. The processing operations are not greatly dissimilar from painting formed metal parts, except that much greater efficiency and improved product quality are attained.

Historical

Coil coating is a relatively young industrial process originating in the mid-1930's as a process for painting stock for venetian blind slats. In this embryonic stage, cleaned (oil free) steel was delivered from the nearby steel mill and painted without further surface treatment. Since then coil coating has grown rapidly. The technology of cleaning metals, conversion coating to provide corrosion protection and improved paint adherence and paints and coatings have improved dramatically and these improvements have been translated into improved quality coil coatings. Today coil coating produces the highest quality painted surface on metals and these products are finding their way into new and more demanding applications.

The coil coating category includes 69 plants of various sizes. Independent shops obtain raw untreated coil and produce a wide variety of coated coil products for specific customers. Sometimes the independent coil coater performs a toll function, coating basis materials owned by the customer. A captive coil coating operation is usually an integral part of a large corporation engaged in many phases of metal production and finishing. The annual square footage for most independent shops is lower than that of captive coil coating operations.

Coil coating facilities generally clean, conversion coat and paint coils of aluminum, galvanized and steel. A number of facilities process all three basis materials. Facilities that process steel almost always process galvanized. About half of the facilities process just aluminum. Production totals from the dcp survey are shown in Table III-1 (page 37) by type of basis material for 1976. Included are total area cleaned, total area conversion coated and total area painted. These production figures represent the actual area coated or painted (sum of both sides of the coil area.) Cleaning and conversion coating are usually performed on both sides of the coil, while painting can be primer and finish coat on one or both sides.

Coil coating facilities purchase blended alkaline cleaners and conversion coating solutions. Process chemical consumption normalized by production rates varies considerably from facility to facility. The dcp data show only a few chemical suppliers for all of the coil coating process chemicals. Some facilities blend purchased pigments, solvents and binders to make their own coating formulations; however, most facilities purchase the blended and formulated paints ready to use. In general, facilities depend heavily on their individual vendors for technical advice for optimum use of purchased chemicals.

Product Description

Coils range in width from a few centimeters to a maximum of about 1.6 m (64 in). The thickness of the coiled basis metal can vary from about 0.25 mm (0.010 in) to about 1.25 mm (0.050 in). A typical coil can range in length from about 600 m (2000 ft) to a maximum of about 12,000 m (40,000 ft). The differences in the basis material, thickness, type of conversion coating and the final finish determine overall strength, appearance, corrosion resistance and price.

The method of paint application reported or observed in the coil coating industry during this study is roll coating. Roll coating provides a finish film of a predetermined thickness. A typical roll coated film applied and cured is about 0.025 mm (0.001 in) thick.

A wide variety of attractive and durable finishes are available that are more efficiently applied and therefore less expensive than other types of paint application techniques.

The finished coils are used in a variety of industries. The building products industry utilizes prefinished coils to fabricate exterior siding, window and door frames, storm windows and storm gutters and various other trim and accessory building products. The food and beverage industries utilize various types of coils and finishes to safely and economically package and ship a wide variety of food and beverage products. Until recently, the automotive and appliance industries have made limited use of prefinished coils, using post assembly finishing of their products. Recently, the automotive industry has begun using a steel coil coated on one side with a finish called zincrometal. This coating is applied to the under surfaces of the exterior automobile sheet metal to protect them from corrosion. The appliance industry appears to be on the threshold of massive use of prefinished coils in appliance construction. One design of refrigerator uses coil coated stock for exteriors which provides a finished product that minimizes the costly and labor intensive painting operation after forming.

Description of Coil Coating Processes

The coil coating sequence, regardless of basis material or conversion coating process used, consists of three functional steps: cleaning, conversion coating and finishing systems. Basically there are three types of cleaning operations used in coil coating, and they can be used alone or in combinations. These are mild alkaline cleaning, strong alkaline cleaning, and acid cleaning. There are four basic types of conversion coating operations and the use of one precludes the use of the others on the same coil. These are chromating, phosphating, complex oxides and no-rinse conversion coating. Some of these conversion coating operations are designed for use on specific basis materials. The painting operation is performed by roll coating and is independent of the basis material and conversion coating. Some specialized coatings are supplied without conversion coating the basis material. The zincrometal is a specialized coating consisting of two coats of special paints that do not require conversion coating. In this process, coils are cleaned, dried, and painted with two coats of the special paints.

Figure III-1 (page 39) shows a typical process sequence. Two coils are mounted at the beginning of the line, one being processed and the other waiting to be processed. Normally coil coating lines are left threaded so that the end of one coil pulls the beginning of the next coil through the process tanks. The accumulator rollers are raised and lowered to allow the downstream end of a coil to keep moving while the coil upstream of the accumulator can remain motionless so it can be joined with another coil. The accumulator allows up to about one minute of time for the end of one coil to be mechanically stitched to the beginning of the next coil at the stitcher. This allows the coil coating line to operate uninterrupted. A take-up reel at the end of the process line pulls the coil through the accumulators and the process tanks. The take-up reel pulls the coil at a rate from about 30m/min (100 ft/min) to a maximum of about 200m/min (700 ft/min). The actual speed is determined by the effective reaction time needed to perform the sequential operations, the physical size of the process tanks, heat capacity of ovens, flow characteristics of the paint, reactivity of the surface, and the speed capability of the take-up rollers.

The selection of basis material, conversion coating and paint formulation is an art based upon experience. The variables that are typically involved in the selection are appearance, color, gloss, corrosion resistance, abrasion resistance, process line capability, availability of raw materials, customer preference and cost. Some basis materials inherently work better with certain conversion coatings, and some conversion coatings work better with certain paint formulations. On the whole however, the choice of combinations is limited only by plant and customer preferences. Table III-2 (page 38) lists the functional operations and the basis material to which each applies.

Cleaning - Coil coating requires that the basis material be clean. A thoroughly clean coil assures efficient conversion coating and a resulting uniform surface for painting. The soils, oils and oxide coatings found on a typical coil originate from rolling mill operations and storage conditions prior to coil coating. Conversion coating operations require that the conversion coating solutions make intimate contact with the basis material without the presence of interfering substances. Such substances can stop the conversion coating reaction, cause a coating void on part of the basis material, and cause the production of a non-uniform coating. Cleaning operations must chemically and physically remove these interfering substances without degrading the surface of the basis material. Excessive cleaning can roughen a basically smooth surface to a point where a paint film will not provide optimum protective properties.

Steel, unless adequately protected with a film of oil subsequent to rolling mill operations, has a tendency to form surface rust rather quickly. This rust on the surface of the metal prevents proper conversion coating. A traditional method of removing this rust is an acid applied by power spray equipment. The spraying action cleans both by physical impingement and the etching action of the acid. The power spray action is followd by a brush scrub which further removes soil loosened by the acid. The brush scrub is followed by a strong alkaline spray wash which removes all traces of the acid and neutralizes the surface.

Aluminum and galvanized tend to develop oxide coatings which act as a barrier to chemical conversion coatings; however, these oxide films are easier to remove than rust and therefore require a less vigorous cleaning process. A mild alkaline cleaner is usually applied with power spray equipment to remove the oxide coating and other interfering substances. Alkaline cleaning solutions are formulated to:

1. Reduce surface and interfacial tensions.
2. Produce active and available alkalinity.
3. Buffer a highly alkaline solution.
4. Soften hard water.
5. Deflocculate, disperse and emulsify removed soils.
6. Be readily rinsed off the work.

7. Provide builders that are compatible with other builders present and are stable within themselves.
8. Be free flowing, dustless and nonhydroscopic in dry form.

The use of alkaline cleaning solutions in power spray equipment requires the solutions to have the following additional features:

1. Be readily soluble.
2. Contain sufficient sequestrant (a material that combines with metal ions to form water-soluble complex compounds).
3. Saponify animal and vegetable oils and greases or emulsify unsaponifiable (mineral) oils.
4. Neutralize acid soils and fluxes.
5. Clean in reasonable time.
6. Have low foaming characteristics.
7. Perform at minimum temperatures.

Soil, mineral oil and protective oxide coatings are removed from the basis materials by a combination of the following five soil removal mechanisms:

- saponification
- emulsification
- dispersion
- flocculation
- film shrinkage

Saponification partially removes animal and vegetable oils from surfaces in the presence of free alkali by forming soaps. Emulsification loosens and suspends oils and soils and produces fine liquid particles which do not settle. Dispersion causes soils and oils to become loosened from the surfaces and spread uniformly about the solution. Flocculation is the process of removing oils and soils from the work surface and causing them to unite either as a settled precipitate or as an agglomerated mass that floats and can be skimmed. Film shrinkage removes oils by disturbing and eventually destroying the angle of contact made by the oil structure at the work surface. The oil removed from the surface subsequently agglomerates and other soil removal mechanisms take over.

Oily soils are of three types: free oils, emulsifiable oils and "soluble" oils. In general, free oils are those which can be separated from solution by simple treatment means such as settling, separation and skimming. Emulsified oils are those suspended in solution that will not separate by settling. Emulsified oils are typically separable through the use of coalescing agents, followed by floatation separation and skimming. "Soluble" oils are typically not truly soluble, but are actually fine emulsions or disperions. Treatment of "soluble" soils typically involves the use of an emulsion breaker prior to flotation by means of foam or dissolved air.

The alkaline cleaning process of the coil coating industry usually involves either free or emulsifiable oils as opposed to "soluble" oils. Mill oils, applied to coils during the milling operation are of the emulsifiable type. Cutting and grinding oils are of the "soluble" type.

Alkaline cleaning solutions exhibit all of these mechanisms. Depending on the exact nature of the oil, dirt, and oxide to be removed, an optimum balance of ingredients can be formulated to produce an effective alkaline cleaner. The cleaning effectiveness of alkaline cleaning compounds is mainly attributed to the physical and chemical action of "builders" which are the bulk components of cleaning formulations. The "builders" provide alkalinity to the cleaning solutions and in combination with water and other active ingredients of alkaline cleaning compounds cause the cleaning solution to exhibit effective soil removal properties. Most builders are sodium compounds such as sodium carbonate, sodium phosphates, sodium silicates, and sodium hydroxide.

Sodium carbonate is a low cost source of alkalinity which serves as a water softener. Carbonates help keep compounded cleaners dry and free flowing during storage. This is important for cleaners with a large proportion of sodium hydroxide. Sodium bicarbonate buffers the pH at a low level of alkalinity which makes the cleaner safe for use on aluminum and galvanized surfaces which would be adversely affected by strong alkalis.

Phosphates serve as water softeners. They impart alkalinity, rinse easily, provide some buffering action and are fair emulsifiers. Trisodium phosphate is the least expensive of the phosphates. It softens water by a reaction that produces insoluble precipitates, which are more desirable than the insoluble gelatinous soaps. Tetrasodium pyrophosphate is a good water softener that sequesters the magnesium and calcium salts found in hard water to form a water soluble complex. This is more desirable than precipitate-forming trisodium phosphate which could cause a sludge buildup in the alkaline cleaning tanks, spray nozzles, and possibly on the basis material. Tetrasodium pyrophosphate is also a good emulsifier, detergent, dispersing and deflocculating agent. Tetrasodium pyrophosphate reverts to orthophosphate in solution depending on pH, temperature and concentration. Sodium tripolyphosphate is the best water softener of the three phosphates. It softens water by sequestration. Sodium tripolyphosphate contributes alkali to a cleaner, but less than the other phosphates. It is beneficial to add a stoichiometric excess of these phosphates to cleaning solutions to offset dilution by water additions and to allow for detergent action.

Silicates make up a portion of heavy duty alkaline cleaners. Silicates are excellent emulsifiers, buffer pH above 9, hold soils in suspension and provide active alkalinity. Sodium orthosilicate is highly alkaline and therefore a very harsh cleaner. Sodium metasilicate is most commonly used in metal cleaners. It is more versatile than other silicates because the ratios of Na_2O to SiO_2 can be adjusted over a wider range by adding sodium hydroxide. This ratio is an important factor in cleaning efficiency and is higher for saponifiable soils.

Sodium hydroxide is inexpensive and is often a principal builder for supplying alkalinity. It increases electrical conductivity and improves saponification. However, sodium hydroxide has poor detergency for saponifiable soils, has poor rinsing properties, and is hygroscopic in dry form.

Soaps and detergents are added to cleaning compounds to lower surface and interfacial tension. Soap (sodium resinate) is often blended with common animal fat soaps such as sodium laurate, palmitate and stearates. Resinates emulsify certain soils and are therefore useful in alkaline cleaners. Synthetic detergents are extensively used as surface-active agents, and they are freer rinsing than soaps, aid soil dispersion and prevent resoiling. Anionics are the least expensive of synthetic detergents. Alkyl aryl sodium sulfonate is the most extensively used anionic. It foams profusely but has good detergency. The nonionics most commonly used are sulfonated esters and ethers and those nonionics of the polyoxyethylene type. These nonionics are a combination of ethylene oxide condensed on a base such as polyoxypropylene. Lower percentages of ethylene oxide make the substance hydrophobic and increase its solubility in oil. Higher percentages increase its solubility in water and its foaming properties. Generally, the ethylene oxide percentages are formulated as high as possible without excessive foaming.

There are several commercially prepared alkaline cleaners that are used by coil coaters. These preparations have very specific uses and each is complete with instructions that describe the optimum concentration. Selection is dependent upon the condition of the base metal.

Following the alkaline cleaning step is a spray rinse. Spray rinsing is conducive to the fast line speeds which make coil coating an economical coating procedure. The spray rinse physically removes alkaline cleaning residues and soil by both the physical impingement of the water and the diluting action of the water. The rinse water is usually maintained at approximately 66°C (150°F) to keep the coil warm for the subsequent conversion coating reactions and to help the rinsing action. The rinsing action prevents contamination of the conversion coating bath with cleaning residues which are dragged out on the strip and could be subsequently deposited in the conversion coating solutions. The rinsing step also keeps the surface of the metal wet and active, which permits faster conversion coating film formation.

The no-rinse conversion coating and the zincrometal processes require a coil that is clean, warm and dry. These processes use a squeegee roll and forced air drying to assure a clean dry coil following alkaline cleaning and rinsing.

Conversion Coatings - The basic objective of the conversion coating process is to provide a corrosion resistant film that is chemically and physically integrally bonded to the base metal and provides a smooth and chemically inert surface for subsequent application of a variety of paint films. Since paint films are not completely impervious to the normal moisture and effects of the ambient atmosphere, a coil that is painted without prior conversion coating can experience premature paint failure. The conversion coating processes effectively render the surface of the basis material electrically neutral and immune to galvanic corrosion. Conversion coating on coils does not involve the use of applied current to coat the basis material. The coating mechanisms are chemical reactions that occur between solution and basis material. Coil coating normally uses four types of conversion coatings:

- Phosphate
- Chromate
- Complex Oxides
- No-Rinse

Phosphate conversion coatings, chromate conversion coatings, and complex oxide conversion coatings are applied in basically the same manner. No-rinse conversion coatings are roll applied and use quite different chemical solutions than phosphating, chromating or complex oxide solutions. However, the dried film is used as basis for paint application similar to phosphating, chromating and complex oxide conversion coatings films.

Phosphate Conversion Coatings - Phosphate conversion coatings provide a highly crystalline, electrically neutral bond between a base metal and paint film. Phosphate coatings have been used since the 1930's to help reduce wear on moving parts and provide corrosion resistance to the basis metal. Currently, the most widespread use of phosphate coatings is to prolong the useful life of paint finishes. Phosphate coatings are primarily used on steel and galvanized surfaces but can be applied to aluminum. The three most popular types of phosphate coatings are iron, zinc and manganese. Manganese coatings are not used in coil coating operations because they are relatively slow in forming and as such are not amenable to the high production speeds of coil coaters.

The remaining two phosphate coatings are applied by spraying or immersing the metal strip; the major difference between them being the weight and thickness of the dried coating. Iron phosphate coatings are the thinnest, lightest and generally the least expensive. They were the first to be used commercially. The iron phosphating solutions in general use today produce a coating of fine crystals of an iridescent blue to bluish brown color. These crystals are translucent so their color is modified by the surface on which they are formed. Iron phosphate solutions are applied chiefly as a base for paint films. Spray application of iron phosphating solutions is most commonly used. The range of coating weights is 0.22 to 0.86 gm/sq m.

Zinc phosphate coatings are quite versatile and can be used as a base for paint or oil, as an aid to cold forming, to increase wear resistance and to provide rustproofing. They encompass a wide range of weights and crystal characteristics varying in color from light to dark grey. Zinc phosphate solutions containing strong accelerators usually produce lighter colored coatings than solutions using milder accelerators. Zinc phosphate coatings can be applied by spray or immersion with applied coating weights ranging from 1.08 to 10.8 gm/m^2 for spray coating and from 1.61 to 43.1 gm/m^2 for immersion coating.

Phosphate coatings are formed in the metal surface, incorporating metal ions dissolved from the surface. This creates a coating which is integrally bonded to the base metal. In this respect, phosphate coatings differ from electrodeposited coatings which are superimposed on the metal. Most metal phosphates are insoluble in water but soluble in mineral acids. Phosphating solutions consist of metal phosphates dissolved in carefully balanced solutions of phosphoric acid. As long as the acid concentration of the bath remains above a critical point, the metal ions remain in solution. Accelerators speed up film formation and prevent the polarization effect of hydrogen on the surface of the metal. Commonly used accelerators include nitrites, nitrates, chlorates, and peroxides. Cobalt, nickel and copper nitrite accelerators are the most widely used and develop a coarse crystalline structure. The peroxides are relatively unstable and difficult to control, while chlorate accelerators generate a fine sludge that may cause dusty or powdery deposits.

A typical heavy metal phosphate coating reaction sequence on a steel basis material is as follows:

First reaction phase: ME = Zn, or Fe (Zinc or iron, cation
part of dehydrogen
phosphate salt)

$$3ME(H_2PO_4)_2 \dashrightarrow ME_3(PO_4)_2 + 4\ H_3PO_4$$

(in water)

The dihydrogen phosphate salt decomposes in solution to form an insoluble phosphate and phosphoric acid when dissolved in water.

Second reaction phase:

$Fe + 2H_3PO_4 \dashrightarrow Fe(H_2PO_4)_2 + H_2$ (Fe, iron is basis material)

The phosphoric acid liberated from the dissociation of the dihydrogen metallic salt and the phosphoric acid normally added to the bath attacks the iron basis material at a nucleation site. This sets up a galvanic reaction with the attack site acting as an anode and a nearby nucleation site acting as a cathode with a subsequent release of hydrogen gas at the cathode. In this reaction, iron from the basis material is physically removed or etched from the surface of the metal and a soluble ferrous phosphate is formed.

Third reaction phase:

$$FE(H_2PO_4)_2 \dashrightarrow FeHPO_4 + H_3PO_4$$

The soluble ferrous phosphate dissociates in solution to form the insoluble iron phosphate and phosphoric acid. The insoluble iron phosphate and the original dissolved metallic dihydrogen salt form the coating.

The overall reaction:

$$3\ ME(H_2PO_4)_2 + Fe \dashrightarrow ME_3(PO_4)_2 + FeHPO_4 + 3H_3PO_4 + H_2$$

The overall reaction involves the dissociation of the metallic dihydrogen salt and subsequent etching of the metal surface. Under the right pH conditions the dissolved basis material ions and the dissociated dihydrogen metallic salt chemically bond themselves to the basis material and effectively stop the reaction by shielding the basis material from further attack by the acid.

The controlling factors that determine the extent and speed of the coating reaction are the amount of phosphoric acid in the bath at equilibrium and the amount of phosphoric acid required to prevent the precipitation of the insoluble metal phosphate. The number of nucleation sites available is a function of the type of metal, the mechanical process the base metal has experienced, and the type of cleaning steps used. Alkaline cleaning normally used in coil coating operations adequately prepares the surface of the basis material to receive a uniform conversion coating.

A rise in pH from equilibrium to the point of incipient precipitation of the metallic phosphate is greatest with iron and the least with zinc. It is believed that smaller crystals result when the coating is produced rapidly. Zinc phosphate solutions require the least amount of acid to be removed from the vicinity of the work piece to raise the pH to the point where the coating starts to form. Larger crystals are formed when larger amounts of acid need to be removed as in the case of iron phosphate solutions.

After phosphating, the coil is passed through a recirculating hot water spray rinse. The rinsing action removes excess acid and un-reacted products, thereby stopping the conversion coating reaction. Insufficient rinsing could cause blistering under the subsequent paint film from the galvanic action of the residual acid and metal salts.

The basis material is then passed through an acid sealing rinse comprised of up to 0.1 percent by volume of phosphoric acid, chromic acid, and various metallic conditioning agents, notably zinc. This solution seals the free pore area of the coating by forming a chromium chromate gel. Also, this acidic sealing rinse more thoroughly removes precipitated deposits formed by hard water in the previous rinses. These deposits can cause problems with subsequent paint films. Modified chromic acid rinses have found extensive use in the industry. These rinses are prepared by reducing chromic acid with an organic reductant to form a mixture of trivalent chromium and hexavalent chromium in the form of a complex chromium chromate.

Chromate Conversion Coatings - Chromate conversion coatings can be applied to aluminum and galvanized surfaces but are generally applied only to aluminum surfaces. The nature of the film and the chemical and physical reactions of its formation are a function and a reinforcement of the naturally occurring protective oxide coatings that are found on aluminum. Chromate conversion coatings produce an amorphous layer of chromium chromate complexes and aluminum ions. These coatings offer unusually good corrosion inhibiting properties but are not as abrasion resistant as phosphate coatings. Scratched or abraded films retain a great deal of protective value because the hexavalent chromium content of the film is slowly leachable in contact with moisture, providing a self healing effect. Most chromate films are soft and gelatinous when freshly formed. Once dried, they slowly harden with age and become hydrophobic, less soluble and more abrasion resistant. However, when freshly formed, these coatings can lose their corrosion resistance with prolonged heating above 55°C (150°F). Chromate coatings result in variegated colors. The thickness of the film is partially responsible for the varying colors. The coating thickness rarely exceeds 0.013 mm. Under limited applications, these coatings can serve as the finished surface without being painted. If further finishing is required, it is necessary to select an organic finishing system that has good adhesive properties. Chromate conversion coatings are extremely smooth, electrically neutral and quite resistant to chemical attack.

Chromate conversion coatings for aluminum are applied from acidic solutions. These solutions usually contain one chromium salt, such as sodium chromate, or chromic acid and a strong oxidizing agent such as hydrofluoric acid or nitric acid. The exact mechanisms that form the film are not completely understood. The final film usually contains both products and reactants and waters of hydration. Chromate films are formed by the chemical reaction of hexavalent chromium with a metal surface in the presence of "accelerators".

The hexavalent chromium is partially reduced to trivalent chromium during the reaction with a concurrent rise in pH. These reactions form a complex mixture consisting of hydrated basic chromium chromate complexes, hydrous oxides of both chromium and the basis material ions, varying quantities of reactants, reaction products and water of hydration, as well as the associated ions of the particular system.

One of the most important factors in controlling the formation of the chromate film is the pH of the solution. For any given metal chromate solution system, there exists an optimum pH which maximizes film formation. As the pH is lowered from this point, the reaction products become increasingly more soluble, tending to remain in solution rather than deposit as a coating on the metal surface. Chemical polishing chromates are purposely operated in a low pH range to take advantage of the increased rate of metal dissolution. The chromate films produced under these conditions are so thin that they are nearly invisible.

Further lowering of the pH converts the chromating solutions into simple acid etchants. Increasing the pH above the optimum gradually lowers the rate of metal dissolution and coating formation to a point where film formation eventually ceases.

The presence of hexavalent chromium is essential but its concentration in chromating solutions can vary widely with limited effects as compared to the effects of fluctuation in pH. Chromate films will not form without the presence of certain anions. These anions are referred to as "activators" and include cyanides, acetates, formates, sulfates, chlorides, fluorides, nitrates, phosphates,and sulfamate ions.

Chromate conversion coating requires that the basis material be alkaline cleaned and spray rinsed with warm water. The cleaning and rinsing assures a clean, warm and wet surface on which the conversion coating process takes place. Once the film is formed it is rinsed and then followed by a chromic acid sealing rinse. This rinse seals the free pore area of the coating, increasing the available hexavalent chromium ion availability. Also, the sealing rinse more thoroughly removes precipitated deposits formed by hard water in previous operations. Next the coil is subjected to a forced air drying step to assure a uniformly dry surface for the following painting operation.

Complex Oxide Conversion Coatings - Complex oxide conversion coatings can be applied to aluminum and galvanized surfaces but are generally applied to only galvanized surfaces. The nature of the film and the chemical and physical reactions of its formation are a function and a reinforcement of the naturally occurring protective oxide coating that is found on galvanized surfaces. The composition of the film is indefinite since it contains varying quantities of reactants, reaction products, water of hydration and dissolved ions associated with the particular system. The physical properties of the complex oxide conversion coating film are comparable to those of chromate conversion coating films and phosphate conversion coating films.

Similar to chromate conversion coating film formation, complex oxide film formation is not as clearly defined as the mechanism for phosphate conversion coating reactions. Complex oxide film formation is formed in a alkaline solution while the other two are formed in an acidic solution. Complex oxide conversion coating reactions do not contain either hexavalent or trivalent chromium ions. However, the sealing rinse contains much greater quantities of hexavalent and trivalent chromium ions than do the sealing rinses associated with phosphate conversion coatings and chromate conversion coatings.

The thickness of a conversion coating is related to immersion time of the basis material, concentration of reactants in the coating solution, temperature and specific formulation (such as the accelerator used). The generation of wastewater is a function of rinsing the unreacted residues and related materials from the coating. This bears little or no direct relationship to the final thickness of the coating.

No-Rinse Conversion Coatings - Recent developments in chromate conversion coating solutions have resulted in a solution that can be applied to steel, galvanized or aluminum without the need for any rinsing after the coating has formed on the basis material. The basis material is normally alkaline cleaned, thoroughly rinsed and forced air dried prior to conversion coating. The conversion coating solution is applied with a roll mechanism used in roll coating paint. Once the solution is roll coated onto the basis material, the coil is forced air dried at approximately 66°C. The no-rinse solutions are formulated in such a way that once a film is formed and dried, there are no residual or detrimental products left on the coating that could interfere with normal coil coating paint formulations.

Although no-rinse conversion coatings currently represent a small proportion of the conversion coating techniques that are used, they offer potential users the following advantages:

- Application of a very uniform thickness of coating at high line speeds with the utilization of roll coating rather than spray or dip coating.

- No monitoring of bath constituents because all constituents are depleted at the same rate by the roll coater.

- Reduction in wastewater treatment requirements because there are no wastewater streams with chromium compounds, except those caused by routine equipment cleaning.

The no-rinse conversion coating disadvantages include:

- Roll coating mechanisms are susceptible to wear. Unfortunately the roll itself is most susceptible to wear and if not watched closely could lower the quality of the applied film.

- Closer coordination of line speed, cleaning solution composition, temperature and pressure of spray rinse and completeness of forced air drying are required. The inherent higher line speed requires that the entire operation be more finely tuned to achieve satisfactory results.

- Existing coil coating lines are difficult and expensive to adapt to no-rinse conversion coating operations.

- No reuse conversion coatings are not FDA approval for food grade coatings.

Painting - Roll coating of paint is the final process in a coil coating line. Roll coating represents an economical method to paint large areas of metal with a variety of finishes and produce a uniform and high quality coating. The reverse roll procedure for coils is used by the coil coating industry. As the name implies, in reverse roll coating the applicator roll rotates opposite to the direction of travel of the coil. Figure III-2 (page 40) illustrates reverse roll coating mechanisms in common use. The metering roll is driven in the reverse direction of the transfer roll. Its speed and distance from the transfer roll ultimately determines the final paint thickness. These mechanisms can be adapted to paint both sides of the coil at once. It is not uncommon for coil coating lines to have two painting stations, the first applying a primer coat to both sides and a second applying a finish coat to one or sometimes both sides.

The paint formulations used in the coil coating industry have high pigmentation levels (providing hiding power), adhesion and flexibility. Most coatings of this type are thermosetting and are based on vinyl, acrylic, and epoxy functional aromatic polyethers, and some reactive monomer or other resin with reactive functions, such as melamine formaldehyde resins. Also a variety of copolymers of butadiene with styrene or maleic anhydride are used in coating formulations. These coatings are cured by oxidation mechanisms during baking similar to those which harden drying oils.

Of prime consideration in roll coating is the use of solvents to control viscosity of the applied paint. In roll coating, only a short period of time (seconds) elapses between the time of paint application and entrance to the curing oven. The paint distribution on the coil determines the smoothness and final appearance of the painted surface. An optimum blend of solvents requires a solvent that evaporates slowly enough to allow a rapid flow of the paint over the coil, but one that evaporates quickly in the curing oven. Typical solvents found in paint formulations, and which may be used in roll coating processes to control viscosity and handling properties are listed below:

Solvent Naptha #2
Solvent Naptha #3
Butyl Carbitol
Cellosolve Acetate
Methyl Ethyl Ketone
n-Hexane
Lacquer Diluent Naphtha
Toluol
Isopropyl Alcohol
Methyl Isobutyl Ketone
Isophorone
Butyl Acetate
Xylol
Methyl Amyl Acetate
Butanol
Amyl Acetate
Hi Flash Naphtha
Cellosolve
Mineral Spirits
Diisobutyl Ketone
Diacetone Alcohol
Butyl Cellosolve

After paint application, the continuously moving strip is cured in an oven. Curing temperatures depend upon basis material, conversion coating, paint formulation and line speed. Typical temperatures range from about 93°C to a maximum of about 454°C. Upon leaving the oven, the strip is quenched with water to induce rapid cooling prior to rewinding. The quench is necessary for all basis materials, conversion coatings and paint formulations. A coil that has been rewound when too warm will develop internal and external stresses, causing a possible degradation of the appearance of the paint film and forming properties of the prepainted strip. The volume of water used in the quench is often large to provide rapid heat transfers. However, the water is often circulated to a sump to provide the necessary large flow and may be passed through a cooling tower for heat dissipation and reuse.

INDUSTRY SUMMARY

The coil coating industry in the United States consists of 69 coil coating plants having 125 coil coating lines. The basis materials coated include steel, galvanized (steel) and aluminum (including aluminized steel). Coil width varies from 25 mm (1 in.) to 1.6 m (64 in.); basis material thickness ranges from 0.25 mm (0.01 in.) to 1.25 mm (0.050 in.); coil length ranges from 600 m (2,000 ft) to 12,000 m (40,000 ft). The coil is thoroughly cleaned and a chemical conversion coating is usually applied to the coil before it is painted. Most paint coatings are based on vinyl, acrylic or epoxy formulations although some specialized coating are also used. Laminating of films to the chemically coated basis material may also be done.

About 1.2 billion m^2 (13 billion sq ft) of coated coils are manufactured annually. The industry uses about 72 million l (19 million gal) per year of organic coatings valued at over $140 million. Some facilities apply over 900 different coatings in one year. The largest market for coated coils is in the building products industry, for products such as roof decks and industrial and residential siding. Transportation is the next largest consumer and uses coated coils for automobile parts. Other major users of coated coils are the appliance and container manufacturers.

The dcp survey showed that about 65 percent of the coil coaters are located in six states: Alabama, California, Illinois, Michigan, Ohio and Pennsylvania. The rest are located throughout the midwest and southeast. About 3,000 employees are directly involved in coil coating.

Coil coating stands out among other metal finishing industries due to its ability to provide a high quality coating and yet conserve raw materials. It is estimated that coil coating uses only one fifth to one sixth the natural gas of post painting and curing. The water used per square meter of coated area is about one tenth as much as is used in most other metal finishing operations. This is one of the reasons EPA is treating coil coating as a separate category.

Due to the ease with which coil lines can be changed to run different basis material, many coil coaters coat two or three basis materials. On the dcp survey, 59 facilities indicated which basis materials they coat. Ten (17%) facilities coil coat exclusively on steel, two (3%) coat exclusively on galvanized, and nineteen (32%) coat exclusively on aluminum. The rest coat on either two or three materials. In total, 35 of the facilities coat steel, 18 coat galvanized, and 41 coat aluminum. Two facilities coat copper or brass on a regular (but not exclusive) basis and most do or can make an occasional run of coated steels.

The total wastewater discharge from coil coating is about 29 million l/day (7.8 million gal/day), with a discharge of an estimated 2,900,000 kg (6.4 million lb) of pollutants in its wastewaters every year. Of 69 coil coaters,, 39 discharge to a publicly owned treatment works (POTW), 29 discharge to surface waters and one has no discharge.

The coil coating industry has various end-of-pipe and various in-process treatments already in place. Approximately 15 percent of the plants have no treatment in place. The most common wastewater treatments in place as indicated in the dcp's are listed below:

Treatment In Place	Percent of Plants
Chemical reduction	71
pH adjust (lime)	39
pH adjust (caustic)	15
pH adjust (acid)	35
Settling tanks	30
Clarifier	29
Cooling tower	22
Equalization	24
Contractor removal sludge	24
Landfill sludge	20

INDUSTRY OUTLOOK

The pattern of strong growth, rapid technological change and product improvement which has characterized the coil coating industry may be expected to continue in the future. New and improved processes and coatings, high product quality, economy of production and control of environmental pollution have allowed coil coated products to penetrate new markets and to displace older painting techniques.

Several innovations have allowed coil coaters to have an economic advantage over other metal finishing processes. The most significant of these is the ability of the coated coil to be bent and formed after being coated without deterioration of the coat or its corrosion resistant properties.

The coil coating industry has experienced strong growth over the period 1962 through 1978. Total coil coated metal shipments have grown at a compounded annual rate of over 12 percent. Growth during the same period for the end-use markets (transportation equipment and building products) have average 3-4 percent for the use of coated metals coils has grown more rapidly than that of other materials. The industry is still expected to be relatively profitable and to grow at a rate at least as great as the GNP through 1985 (which has averaged around 3 percent in real terms since World War II).

TABLE III-1

Annual Coil Coating Production in 1976*

	Cleaned square meters (square feet)	Conversion Coated square meters (square feet)	Painted square meters (square feet)
Cold Rolled Steel	487.60 X 10^6 (5,249 X 10^6)	379.66 X 10^6 (4,087 X 10^6)	544.00 X 10^6 (5,856 X 10^6)
Galvanized Steel	230.00 x 10^6 (2,475 X 10^6)	225,80 X 10^6 (2,430 X 10^6)	380.8 X 10^6 (4,099 X 10^6)
Aluminum	1,395.84 X 10^6 (15,025 x 10^6)	1,288.14 X 10^6 (13,865 X 10^6)	1,006.3 X 10^6 (10,832 x 10^6)
Total	2,113.44 X 10^6 (22,749 X 10^6)	1,893.60 x 10^6 (20,383 X 10^6)	1,431.16 X 10^6 (20,787 X 10^6)

*Data based upon DCP's and visited plants, areas as listed are total area applicable to each operation. Cleaning and conversion coating areas are total area of both sides of coil. Painted area accounts for multiple coats on one or both sides of coil.

TABLE III-2

TYPICAL OPERATIONS FOR EACH BASIS MATERIAL

	STEEL	GALVANIZED	ALUMINUM
Cleaning			
Acid Cleaning	X		
Mild Alkaline Cleaning		X	X
Strong Alkaline Cleaning	X		
Conversion Coating			
Phosphating	X	X	X
Chromating		X	X
Complex Oxide		X	X
No-rinse Conversion Coating	X	X	X
Roll Coating	X	X	X
Zincrometal Coating	X		

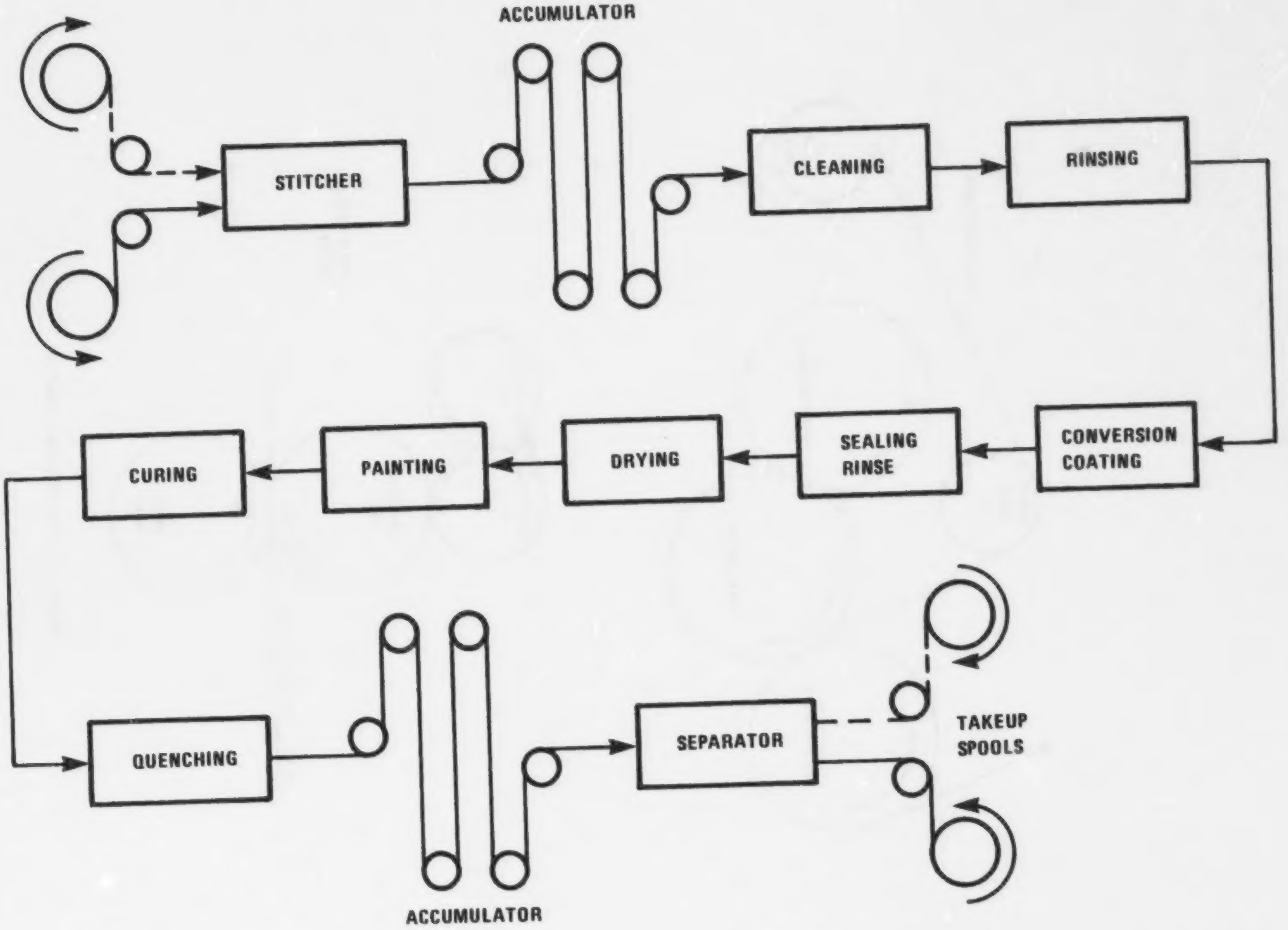

ACCUMULATOR
STITCHER
CLEANING
RINSING
CONVERSION COATING
SEALING RINSE
DRYING
PAINTING
CURING
QUENCHING
ACCUMULATOR
SEPARATOR
TAKEUP SPOOLS

FIGURE III-1. GENERAL PROCESS SEQUENCE FOR A SINGLE COAT COIL COATING LINE

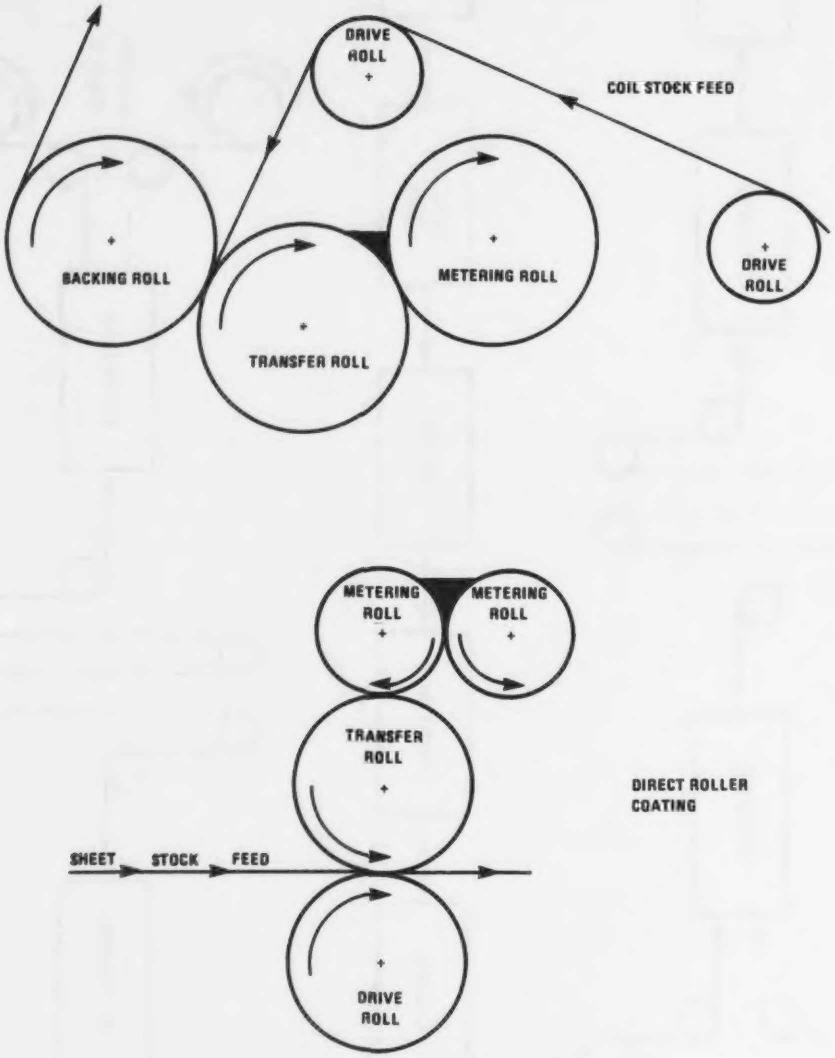

DRIVE ROLL
COIL STOCK FEED
BACKING ROLL
METERING ROLL
TRANSFER ROLL
DRIVE ROLL
METERING ROLL
METERING ROLL
TRANSFER ROLL
DIRECT ROLLER COATING
SHEET STOCK FEED
DRIVE ROLL

FIGURE III-2. REVERSE ROLL COATERS

SECTION IV

INDUSTRY SUBCATEGORIZATION

Subcategorization should take into account pertinent industry characteristics, manufacturing process variations, wastewater characteristics, and other factors which do or could compel a specific subcategorization. Effluent limitations and standards apply to the discharge of pollutants. In this regulation, limitations and standards are mass based to allow the national standard to be applied to the full range of sizes of production units, the mass of pollutant discharge must be referenced to a unit of production. This factor is referred to as a production normalizing parameter and is developed in conjunction with subcategorization.

Division of the industry segment into subcategories provides a mechanism for addressing process and product variations which result in distinct wastewater characteristics. The selection of production normalizing parameters provides the means for compensating for differences in production rates among plants with similar products and processes within a uniform set of mass-based effluent limitations and standards.

SUBCATEGORIZATION BASIS

Factors Considered

After considering the nature of the various segments of the coil coating industry and their operations, EPA evaluated possible bases for subcategorization. These include:

1. Basis Material Used
2. Manufacturing Processes
3. Wastewater Characteristics
4. Products Manufactured
5. Water Use
6. Water Pollution Control Technology
7. Treatment Costs
8. Solid Waste Generation and Disposal
9. Size of Plant
10. Age of Plant
11. Number of Employees
12. Total Energy Requirements (Manufacturing Process and Waste Treatment and Control)
13. Non-Water Quality Characteristics
14. Unique Plant Characteristics

Subcategorization Selection A review of each of the possible subcategorization factors reveals that the basis material used and the processes performed on these basis materials are the principal factors affecting the wastewater characteristics of plants in the coil coating industry. The most logical factors for subdivision of this industry are the manufacturing processes performed and the basis materials that are processed. This is because both the process chemicals and the basis material constituents can appear in wastewaters. The major manufacturing processes in the coil coating industry are cleaning, conversion coating, and paint application. Wastewater from cleaning and conversion coating are dependent on the basis material processed, while wastewaters from the paint application step are independent of the basis material. Therefore, subcategorization by basis material inherently accounts for the process chemicals used. The three principal basis materials are steel, zinc coated steel and aluminum and these form the principal basis for the following subcategories.

a. Coil coating on steel
b. Coil coating on zinc coated steel (galvanized)
c. Coil coating on aluminum or aluminized steel

(NOTE: For ease of reference the basis material and subcategories are referred to as steel, galvanized and aluminum throughout this document. The terms "basis material" and "subcategory" are used interchangeably.)

Minor variations in basis materials are occasionally encountered. Aluminum coated steel may be coil coated and is considered as aluminum. A small amount of coated steels (e.g. chrome, nickel and tin) are coil coated and are considered for the purpose of effluent limitations and standards as steel. Similarly, small amounts of galvalum (a zinc-aluminum alloy) and brass (copper-zinc alloy) and very small amounts of other copper forms are considered as galvanized. Grouping these minor materials with major segments will ensure appropriate limitation while minimizing regulatory complexity.

One potential limitation of subcategorization based solely on the basis material processed is painting performed without conversion coating. Since neither additional pollution is caused nor an additional pollutant is created by this process there is no need for concern.

Subcategorization by basis material used is the most logical method for segmenting the industry because it focuses on the source of wastewaters. It is also an easily recognized way of separating and designating subcategories. Other subcategorization bases considered but not recommended for subcategorization are presented in the following subsections along with the reasons why they are not as appropriate as the approach selected.

Products Manufactured

The product produced by coil coating is the painted basis material which is essentially the same throughout the industry and thus does not provide a basis for subcategorization.

Water Use

Water usage alone is not a comprehensive enough factor upon which to subcategorize because it is dependent on the specific manufacturing process and basis material used. While water use is a key element in the limitations established, it does not inherently relate to the source or the type and quantity of the wastewater.

Water Pollution Control Technology and Treatment Costs

The necessity for a subcategorization factor to relate to the raw wastewater characteristics of a plant automatically eliminates certain factors from consideration as potential bases for subdividing the industry. Water pollution control technology and treatment costs have no effect on the raw wastewater generated in a plant. The water pollution control technology employed at a plant and its cost are the result of a requirement to achieve a particular effluent level for a given raw wastewater load. It does not affect the raw wastewater characteristics.

Solid Waste Generation and Disposal

Physical and chemical characteristics of solid waste generated by the coil coating industry are determined by the basis material. Furthermore, solid waste disposal techniques may be identical for a wide variety of solid wastes and do not provide a sufficient basis for subcategorization.

Size of Plant

The nature of the processes for the coil coating industry are the same in all facilities regardless of size. The size of a plant is not an appropriate basis for subcategorization because the wastewater characteristics of a plant per unit of production are essentially the same for plants of all sizes when processing the same basis material. Thus, size alone is not an adequate basis for subcategorization since the wastewater characteristics of plants depend on the type of products produced.

While size is not adequate as a technical subcategorization parameter, EPA recognizes that the capital investment for installing wastewater control facilities may be greater for small plants relative to the investment in their production facilities than for larger plants. Consequently, the size distribution of plants was investigated during the development of limitations and wastewater treatment technology recommendations were reviewed to determine if special considerations are required for small plants.

Age of Plant

While the relative age of a plant is important in considering the economic impact of a guideline, it is not an appropriate subcategorization basis because it does not take into consideration the significant parameters which affect the raw wastewater characteristics. Plant processes employed have a much more significant impact on the raw wastewater generated than the age of the plant. In addition, a subcategorization based on age would have to distinguish between old plants with old equipment, old plants with new equipment, new plants with old equipment and every other possible combination. Plants would have to be carefully reviewed to insure they are accurately placed within a subcategory. Furthermore, the dcp's returned from plants in this industry indicate that the industry is relatively new and that most plants are fairly young.

Number of Employees

The number of employees in a plant does not directly provide a basis for subcategorization as the number of employees does not necessarily reflect the production or water usage rate at any plant. Rather, the operational time of any given basis material and paint color or finish without production stoppage determines the production rate. A plant with six employees that changes basis materials frequently may produce less than a plant with two employees that produces a single finish on a single basis material for an extended period of time. The amount of wastewater generated is related to the production rates and the number of employees does not provide a definitive relationship to wastewater generation.

Total Energy Requirements

Total energy requirements were excluded as a basis for subcategorization primarily because of the difficulty in obtaining reliable energy estimates specifically for production and wastewater treatment. When energy consumption data are available, they are likely to include other energy requirements such as lighting, air conditioning, and heating as well as energy required to run the plant and treatment facility.

Non-Water Quality Aspects

Non-water quality aspects may have an effect on the wastewater generated in a plant. A non-water quality area such as air pollution discharges may be under regulation and water scrubbers may be used to satisfy such a regulation. This could result in an additional contribution to the plant's wastewater. However, it is not the prime cause of wastewater generation in coil coating, and is therefore not acceptable as an overall subcategorization factor.

Unique Plant Characteristics

Unique plant characteristics such as geographical location, space availability, and water availability do not provide a proper basis for subcategorization as they do not affect the raw wastewater characteristics of the plant. The dcps reveal that plants in the same geographical area have different wastewater characteristics. Process water availability may be a function of the geography of a plant and the price of water determines any necessary modifications to procedures employed in each plant. However, required procedural changes to account for water availability only affect the volume of pollutants discharged, not the characteristics of the constituents. Wastewater treatment procedures can be utilized in any geographical location.

A limitation in the availability of land space for constructing a wastewater treatment facility may affect the economic impact of an effluent limitation. However, in-process controls and rinse water conservation can be adapted to minimize the land space required for the end-of-process treatment facility. Often, a compact treatment unit can easily handle end-of-process waste if good in-process techniques are used to conserve raw materials and water.

Summary of Subcategorization

For this study, the Agency has determined that the principal factor affecting the wastewater characteristics of plants in the coil coating category is the basis material used. The basis material dictates the type of preparation required, thus affecting the wastewater characteristics. This is the same subcategorization scheme that the Agency proposed for this regulation, and no public comments criticized it.

PRODUCTION NORMALIZING PARAMETERS

Coil coating, like most metal surfacing processes, is processed area dependent. The amount of chemicals and other raw materials used and the amount of wastewater and wastewater pollutants is proportional to the surface area processed. For this reason surface area is the first production normalizing parameter (PNP) considered. Since it is an easily measured quantity that is available from industrial production records, it is a prime candidate to be the PNP for coil coating. The area processed is the area which comes into contact with process chemicals and solutions and includes both sides of the strip.

EPA also considered the amount of process chemicals used as a PNP in effluent limitations and standards development. Process chemicals may differ from coating line to coating line. Also because of the proprietary nature of many coil coating preparations it can be difficult to determine the actual consumption of specific material.

Water use also was considered; however, Tables V-6 through V-8 (pages 77-78) reveal that there is no direct relationship between water use and the amount of product manufactured.

The weight of product manufactured was considered; however because the basis material thickness may vary over a 5 times range, mass was rejected from further consideration.

EPA has determined that the area of basis material cleaned or conversion coated is the most logical and useful production normalizing parameter.

SECTION V

Water Use and Wastewater Characterization

This section presents summaries and supportive data which describe and characterize coil coating water use and wastewater. Data collection and data analysis methodologies are discussed. Raw wastewater and final effluent constituents, flow rates and pollutant mass per unit of production area are presented for the three basis material subcategories and for specific functional operations in each.

INFORMATION COLLECTION

EPA collected information from a number of sources about the coil coating industry. Some existing information was found in the Agency: a previous study done by EPA; permits for coil coaters who discharge to surface waters, and information that was collected concurrently by the Office of Air Quality Planning and Standards. EPA conducted a literature search to find pertinent published information about the coil coating industry. Technical information was provided by industry representatives and the industry trade association. Information requests were sent to all known coil coating companies and also to several chemical suppliers. The greatest amount of specific data was collected during the sampling program conducted prior to proposal. Finally further information and help in identifying problems was provided by commenters to the proposed regulation and supporting development document.

A previous Agency study of the coil coating industry was reviewed at the outset of this study. Although this study was not published, it had gathered information on a number of coil coating facilities and on the industry in general. Most of this information was used to develop an overview of the industry and identify a preliminary data base.

The National Pollutant Discharge Elimination System (NPDES) permits for coil coating facilities which had a direct discharge stream were obtained from the Regional EPA offices and from the Ohio EPA where applicable. In several cases, the permits involved streams other than coil coating wastewaters, e.g. noncontact cooling water. Some facilities directly discharge only the quench wastewaters or the cleaning wastewaters after treatment; other plant wastewaters are discharged to a Publicly Owned Treatment Works (POTW). The Agency was hoping to learn current industry practices for wastewater treatment; however, the information in the permits was insufficient for this purpose.

The permits did not specify where the discharge streams originate and it was not possible to determine if noncontact cooling water was being mixed into the discharge stream or if other processes not under the coil coating category were included in the discharge. It also was not possible to relate the permit limitations to production which precluded any analysis for effluent limitations except by concentration. For these reasons, the permit information had very little impact on this study.

The Office of Air Quality Planning and Standards conducted a study concurrently with this study on a category similar to the coil coating category. Although some information was shared between the two studies, the information was not significant and focused on different processes.

EPA conducted a literature search to obtain as much pertinent published material about the coil coating industry as possible. Information was collected on the processes used, the purpose of and theory behind each process, the chemicals used, the economics of the processes, the methods of conserving water, and the methods of treating wastewaters from the coil coating industry. Some of this informaton is summarized in Section III.

Industry representatives and the National Coil Coaters Association provided information throughout the development of this study. Wastewater treatment systems and their effectiveness on coil coating wastewaters, new and upcoming technologies and processes which might impact regulatory decisions or options, and other aspects far too numerous to list were discussed with or provided to the Agency.

Data requests were sent to every known coil coating facility and to several chemical suppliers. The data received from the chemical suppliers concerned the chemical constituents of their proprietary chemical baths. This information is confidential and does not appear in this report. It did, however, guide the Agency on where to look for pollutants and what pollutants to expect. The data requested of the individual companies involved in coil coating operations are described in more detail later in this section.

The sampling program is described later in this section.

Comments on the proposed development document were assimilated and incorporated into this report when applicable. The comments ranged in topics from the general operating procedures of a coil coating plant to the problems involved in wastewater treatment systems and how they relate to coil coating.

PLANT DATA COLLECTION

The Agency collected technical data for this report prior to proposal. A preliminary review of the existing coil coating information indicated the need for more extensive plant data. This data was collected through a mail survey which involved several activities: the development of a data collection portfolio; the distribution of the survey, logging of the survey responses, examination and analysis of the information received; selection of plants for on-site sampling of raw and treated process wastewaters; and the implementation of sampling programs at selected plant sites.

Development of the Data Collection Portfolio - After review and analysis of the existing data, the Agency developed a draft data collection portfolio. Information was requested about plant age, production, number of employees, water usage, manufacturing processes, raw material and process chemical usage, wastewater treatment technologies, the known or believed presence or absence of toxic pollutants in the plant's raw and treated process wastewaters, and other pertinent factors.

Representatives of the National Coil Coaters Association (NCCA) were invited to meet with EPA, to review the draft data collection portfolio, and to offer comments.

Comments received from the NCCA were reviewed and where appropriate, were incorporated into the final data collection portfolio. In addition to this input, EPA was in communication with the NCCA throughout the entire program in order to utilize their knowledge of coil coating practices.

Survey Design - The Dunn and Bradstreet Index lists the products of businesses by Standard Industrial Classification (SIC) code. A computer search of the SIC codes, 3479 and 3497 (most commonly used by coil coaters) was done for primary and secondary industries of these companies. The list of coil coaters obtained from this search was supplemented by the companies who were members of the NCCA and by the companies who were known to be involved in coil coating from the previous study the EPA conducted. In all 68 companies were identifed as probably being involved in coil coating operations.

Distribution of the Plant Survey - Each company on the mailing list was sent a dcp along with a statement explaining the recipient's legal rights to protection of confidential information and EPA's statutory authority under Section 308 of the Federal Water Pollution Control Act as amended, for requesting the needed data. Data was requested on all coil coating operations of each company. Particularly, data pertinent to the 1976 calendar year was requested. In addition, the dcp briefly explained the settlement agreement background leading to the request and set a 45 calendar day time period for responding to the information request.

Processing of Survey Responses - Each response was logged in and examined for claims of confidentiality. Information claimed to be confidential or proprietary was segregated from other information and was processed according to the statutory requirements for handling information claimed to be confidential.

Sixteen of the responses were returned with an indication that the company either was no longer in business, or that the company was not involved in coil coating operation. None of the information requests were returned as undeliverable at the address indicated.

Plant responses were then copied and the copy forwarded to the technical contractor. The plant information was examined for completeness and interpretation, and prepared for computer entry and analysis by the technical contractor. Each facility was assigned a four or five digit identification number which is used throughout the study and this document for identification. At the end of the 45 day response period, a follow up letter was sent to those establishments which had not responded. All companies who were sent an information request responded.

In total, information on 72 facilities was received. Three plants did not perform coil coating. The remaining 69 facilities operate about 125 coil coating lines. Although the Agency was not able to locate all of the coil coating facilities reported to exist (some sources have estimated as many as 190 coil coating lines in the United States), the majority were believed to be located and information was received on each of these facilities.

Selection of Plants for Sampling - Information from the data collection portfolio served as the primary basis for selection of plants for engineering and sampling visits. Specific criteria used to select plants for visits included:

- Equal distribution of sampling days among the three subcategories.
- Inclusion of plants with high and low water use and varying numbers of coil lines in the sampling program.
- Manufacturing processes that are representative of the industry as a whole.

- Operating wastewater treatment systems or water conservation methods.

Engineering visits were conducted at 18 facilities to supplement dcp information and to review plants for possible sampling visits. Sometimes the engineering visits were combined with the sampling visits.

Thirteen plants were selected for sampling, most of which were equipped to process two or all three basis materials. Thus, several of the plant sampling visits provided process and wastewater information in more than one subcategory. To make sampling easier, EPA tried to select plants which process only one basis material. Except for the aluminum subcategory, however, it was found that most facilities which process only one basis material did not meet the selection criteria as well as those plants which processed more than one. Therefore, several plants which processed more than one basis material were chosen. Table V-1 (page 60) lists the sampled plants in each subcategory and the number of sampling days on which data were collected for that subcategory. It also indicates the plants where screen sampling was done.

SAMPLING PROGRAM

Two sequential procedures are used for sampling - screening followed by verification. When a facility is chosen for screening, samples are taken at various streams of interest. The Agency has established a protocol for gathering, shipping, and analyzing these samples which is detailed in "Screening and Analysis Procedures for Screening of Industrial Effluents for Priority Pollutants," March, 1977 revised April, 1977, U.S. EPA (short form of title: "Screening Protocol"). The samples for screening are analyzed for the 129 priority pollutants and any other pollutants deemed necessary. From the results of screening, a number of pollutants found in significant quantities are selected for verification. The samples gathered under the verification sampling program are analyzed only for those pollutants selected from the screening results. The method of gathering, shipping, and analyzing the samples for verification is detailed in "Analytical Methods for the Verification Phase of the BAT Review," June, 1977, U.S. EPA (short form of title: "Verification Protocol"). One screening visit is carried out for each subcategory. For coil coating, therefore, three facilities were selected for screening, two of which were also used for verification. Ten other facilities were selected for verification.

Methodology - Prior to sampling visits, all available data, such as layouts and diagrams of the production processes and waste treatment facilities were gathered and reviewed. Before conducting a visit, a detailed sampling plan showing the selected sample points was generated. Pertinent data to be obtained was detailed. For all sampling programs, flow proportioned composite samples, or the equivalent for batch operations, were taken while the plant was in operation.

The main purpose of the screening program was to determine what pollutants were being introduced into the wastewaters of plants in each subcategory. Plants were selected for screening when it was possible either to sample total raw wastewater or to make a flow proportioned composite equivalent of the total raw wastewater. The total raw wastewater is a sample taken where the process water from all processes has mixed prior to any treatment. Many wastewaters, however, receive some preliminary treatment before mixing (i.e., chromium wastewaters were generally treated to reduce hexavalent chromium before being mixed with other wastewaters). When this was the case in a screening plant, the stream was also sampled prior to the individual stream treatment. Inlet water to the plant was also sampled to determine the pollutant levels of incoming water. A sample of the effluent after treatment was taken to determine the effectiveness of the wastewater treatment system, and to see if any pollutants were introduced by the treatment system itself. A blank sample is taken to see if any pollutants are being introduced into the other samples by the sampling equipment. A blank is made by pouring specially preparied organic free water through the sampling equipment and handling it just as the other samples.

The verification process determines the sources and levels of pollutants in wastewaters. Verification samples are taken for every operation which discharges or uses process water, including any rinses following a treatment process. These are all sampled as one operation. The concentrations of parameters in the inlet water to the plant are measured to see if pollutants are not actually being introduced but are present at background levels in the water being used. The final effluent is measured to determine the effectiveness of the wastewater treatment system. When streams were treated and discharged separately, all of the effluents were measured.

Table V-2 (pages 61-66) lists the methods used to analyze the samples collected during screening and verification. Because only a few of the pollutants analyzed for in screening are analyzed for in verification, most of the "Verification Analysis Methodology" column is blank.

Verification Parameter Selection - In order to reduce the volume of data which must be handled, avoid unnecessary expense, and direct the scope of the sampling program, a number of the pollutant parameters analyzed for during the screen sampling are not analyzed for during the verification sampling. The pollutant parameters which are chosen for further analysis are called verification pollutant parameters. Due to the different pollutants present in each subcategory, EPA selects verification pollutant parameters separately for each subcategory. Three sources of information were used: pollutants believed to be present by industry; pollutants indicated by the screen sampling analyses; and pollutants selected by the Agency after review of the processes and materials used by the industry.

In the dcp survey, the 129 priority pollutants were listed and each facility was asked to indicate for each particular pollutant "Known To Be Present" (KTBP), "Believe To Be Present" (BTBP), "Believe To Be Absent" (BTBA), or "Known To Be Absent" (KTBA). KTBP and KTBA were to be indicated if the pollutant had been analyzed for and either detected or not detected. BTBP and BTBA were to be indicated if it was or was not possible for the pollutant to be introduced into the wastewater and the pollutant had not been analyzed. The results of the survey are shown in Table V-3 (pages 67-71). The column to the far right "Screening Raw Wastewater Range", summarizes the range of concentration of the pollutants that were found in the screening samples of total raw wastewater. For simplicity, the dcp data were not divided into the three subcategories since a number of plants fall into more than one subcategory. It should be noted that some facilities completed this portion of the dcp only partially and some not at all. Thus, there are only 60-63 facility responses. Six pollutants were often identified as present (KTBP or BTBP): chromium, copper, cyanide, lead, nickel, and zinc.

Screen samples were taken at three points: the inlet water to the facility, the total raw waste, and the final effluent. The aluminum subcategory required an additional sample of quench water, which is not mixed with the other wastewaters. A quality control blank also was taken. Three facilities were visited for screen sampling, one in each subcategory. The results of the screen sample analyses are in Table V-4 (pages 72-76). Besides the 129 priority pollutants, a number of other conventional and nonconventional pollutants were analyzed.

The verification parameters that were selected are displayed in Table V-5 (page 77). A priority pollutant was not selected if its reported concentration in the raw wastewater was below the limits of analytical quantification (≤0.010 mg/l) except where dcp data or technical judgment based on knowledge of the industry indicated it should be selected. If the concentration of the pollutant in the raw wastewater was greater than 0.010 mg/l it was selected as a verification parameter unless: 1) dcp responses and technical knowledge of the industry indicated that the pollutant should not result from coil coating processes; 2) the pollutant's concentration was below the probable ambient water criteria (PAWC) level. A pollutant detected below the PAWC was considered as not causing or likely to cause toxic effects; 3) the concentration in the raw waste was not significantly higher than in the influent concentration.

DATA ANALYSIS

The verification parameters were analyzed for in all the samples collected during the verification sampling program, for which about five plants were visited (see Table V-1, page 60) for each subcategory. Verification is used to localize the sources of pollutants. Usually samples were taken of the wastewaters from the cleaning baths and succeeding rinses, the conversion coat bath and succeeding rinses (including the acidulated or sealing rinse), the water quenches after baking, and the final effluent from the plant after wastewater treatment. The production and flow of each process were recorded for each day of the verification visit for each plant. Some of this data was also collected during screen sampling and analysis.

Essentially, five pieces of information were derived from the data for further analyses: 1) the production normalized water use (l/m^2) of the individual functional processes and the total coil coating process; 2) mean flows for each process for each subcategory; 3) the median pollutant levels, both concentration and production normalized, of the raw wastewaters from the individual functional processes and the total of all processes. 4) the pollutant levels, both concentration and production normalized, of the final effluents after wastewater treatment; and 5) the maximum pollutant levels and number of occurrences of each in each process.

Throughout this document, mean and median values were taken after the not detected values had been eliminated, except where appropriate. When a pollutant is not found (not detected) in a particular stream usually the pollutant is not entering the wastewater in that plant or sample point. To include pollutants that were not detected in determining mean and median values would therefore unfairly bias the means and medians towards the lower pollutant levels. The number of data points used to calculate the mean and median value, and the number of not detected values that were excluded, are usually presented to the right of the tables of mean and median values. These rules, however, are inappropriate for hexavalent chromium and cyanide amenable to chlorination. If cyanide (total) is detected it must be assumed that cyanide is used in the process. Therefore, if cyanide amenable to chlorination could also be present, it should be (and was) included in the mean and median values even if not detected. The same is true of hexavalent chromium.

The statistical analyses of data include some data points of pollutants measured at levels considered not to be quantifiable. All organics except pesticides and cyanide are not considered quantifiable at concentrations equal to or less than 0.010 mg/l. Pesticides are not considered quantifiable at or below 0.005 mg/l. The distinction of not quantifiable is made because the analyses used to measure the concentrations of the particular pollutants is not quantitatively accurate at the extremely minute concentrations. The analyses are useful, however, to indicate presence of the particular pollutant. Therefore, the data points considered to be not quantifiable were included in the data analyses. This was done by considering a not quantitative value to be equal to 0.000 mg/l. A concentration of zero instead of 0.010 mg/l (0.005 mg/l for pesticides) was selected so as not to bias the statistical analyses to the high side even though minutely. For example, when two or more streams were proportioned to get a total discharge stream for cleaning the total discharge concentration was considered not quantifiable only if the total concentration was calculated exclusively from not quantifiable values. A value of 0.001 mg/l for an organic is considered quantifiable if it results when a stream with a concentration of 0.020 mg/l is diluted 20 fold. When a not quantifiable value appears in a statistical table it is represented by an asterisk. When not quantifiable concentrations were converted to a production normalized level (mg/m^2) the designation as not quantifiable was retained and the analyses were done by the same rules as by concentration.

Water Use

Water is used in virtually all coil coating operations. It provides the mechanism for removing undesirable compounds from the basis material, is the medium for the chemical reactions that occur on the basis material and cools the basis material subsequent to baking. Water is the medium that permits the high degree of automation associated with coil coating and the high quality of the finished product. The nature of coil coating operations, the area of basis material processed, and the quantity and type of chemicals used produces a large volume of wastewater that requires treatment before discharge.

The production data and water use data obtained from the dcp's for the steel, galvanized and aluminum subcategories are shown in Tables V-6, V-7, and V-8 (pages 78, 79, and 80) respectively. The area cleaned, area conversion coated, area painted, and production capacity were reported in the dcp's for each facility. The area cleaned and the area conversion coated represent both sides of the coil. The area painted represents the actual area painted, which may be one side, both sides or multiple coats to one or both sides. The average production rate is calculated in most cases by taking the total production area (length times width) for a whole year for all basis materials and dividing by the total number of hours of operation of all lines in the facility for the whole year.

There were five exceptions where the information reported in these dcp's was insufficient to calculate separate average production rates for each basis material - plant ID 04092, 11077, 11142, 20056 and 36036. These five faciities were not included in Table V-6,7 and 8 because of insufficient data. The process water rate is the sum of all coil coating effluents excluding noncontact cooling water.

The water use is the volume of water used to process a specified area of coil. The water use is equal to the process water rate divided by twice (to account for both sides of the coil) the average production rate. The facilities in Tables V-6, V-7, and V-8 were ordered in ascending average production to see if any dependence of water usage rate on facility size exists. None was apparent.

Tables V-9, V-10, and V-11 (pages 81, 82, and 83) present the water use data from the visited plants by subcategory; steel, galvanized, and aluminum, respectively. The processed area is defined as the area of both sides of the coil (length times the width of the coil times two) since both sides are processed. The water use is determined by dividing the volume of water used by the processed area of the coil. The statistics of the water use from Tables V-9, V-10, and V-11 and from the dcp data in Tables V-6, V-7, and V-8 are summarized in Table V-12 (page 84).

In all three subcategories the numerical values of the production normalized flows have changes from proposal. The changes are based on a re-examination of visited plant and dcp data.

Incoming Water Analysis - Incoming water samples were collected for each sampled plant and analyzed for all of the verification (and screening where applicable) parameters. Overall, these analyses revealed a very few parameters at concentrations above the minimum quantifiable limit of the specific method. The concentration levels found in the incoming water of parameters common to process discharges were not significant enough to affect the anticipated design of a wastewater treatment system. Where incoming water concentrations of regulated parameters are of a significant level, the environmental impact will be assessed on a case by case level by the respective regulatory authorities.

Raw Wastewater Analysis - Coil coating operations that produce wastewater are characterized by the pollutant constituents associated with respective basis materials. Efforts were made during verification sampling to obtain discrete samples of each operation (cleaning, conversion coating and painting). The constituents in the raw wastewaters sampled included ions of the basis material, oil and grease found on the basis material, components of the cleaning and conversion coating solutions, and the paints and solvents used in roll coating of the basis materials.

The coil coating processes are nearly the same in every facility. However, the process lines of each of the sampled plants are summarized in Table V-13 (page 85) to give the reader an idea of each facility. Of the thirteen plants sampled, three claimed confidentiality. The process line summaries have been deleted for these plants.

The statistical analyses of data in the rest of this section are done by two methods, concentration and production normalized. The concentration of the pollutant is the value actually determined by analysis in each process. The analysis by concentration is useful in understanding the functionality of each process. High concentrations of particular constituents in a wastewater stream are indicators of the type of chemical reactions or mass transfer operations taking place. Concentrations do not indicate the amount of pollutants being introduced into wastewaters since a very small stream with high pollutant concentrations may contribute far less pollution than a very large stream with smaller pollutant concentrations. The production normalized levels of pollutants for each process are the mass of a pollutant released in processing a certain area of coil. For each concentration of a pollutant for each sample taken the corresponding production normalized level was determined. The production normalized level was determined by multiplying the pollutant concentration by the water use for that particular process, plant, and day (found in Tables V-9, V-10, and V-11). The analysis by production normalized levels is helpful in determining where absolute quantities (mass) of pollutants are produced.

Tables V-14 through V-27 present the statistical analysis of the data base. The minimum, maximum, mean, and median values of the sampling results are given. The tables are grouped by subcategory. Tables V-14 through V-17 (pages 86-89) contain the cleaning and conversion coating raw wastewater statistical data for the steel subcategory by concentration and by production normalized levels. Similarly, Tables V-18 through V-21 (pages 90-93) present this data for the galvanized subcategory and Tables V-22 through V-25 (pages 94-97) present these data for the aluminum subcategory. The quench data was not divided into subcategories because the raw wastewater from the quench stream was found not to vary significantly among the subcategories. The statistical data for the quench stream is presented in Tables V-26 and V-27 (pages 98 and 99).

Tables V-28 through V-30 (pages 100-102) summarize the medians presented in Tables V-14 through V-26. All medians below or equal to 0.010 mg/l have been deleted to focus attention on those pollutants at significant levels. Table V-31 (page 103) summarizes the total raw wastewaters for each subcategory. They are obtained by flow proportional summing of the individual process stream medians.

The reasons why particular pollutants are present in each raw wastewater stream are discussed in later sections.

Only limited amounts of raw wastewater data were received in the dcp responses. The data was only for a few metals and was not useful.

The water used in each process for each subcategory was determined from the median water flow rate measured during sampling. The median water flow rate (l/day) for each process by subcategory can be found in Tables V-28, V-29, and V-30. The percent of water used in each process is:

Percent of Subcategory Water Use by Process

	Steel	Galvanized	Aluminum
Cleaning	36	25	19
Conversion Coating	7	9	10
Quenching	57	66	71

Effluent Analysis - The diversity of wastewater treatment methods is almost as great as the unformity of the process steps for the coil coating industry. The treatment methods of the sampled plants are summarized in Table V-32 (pages 104 and 105). The three facilities which claimed confidentiality have been deleted.

Samples of the final effluents were taken for every day of sampling. Since a number of facilities had two or more coil coating discharges, samples were taken of each effluent. Some effluents contained wastewaters or treated wastewaters from more than one coil coating line.

Tables V-33 through V-38 (pages 106-113) show the effluent data from the sampled plants for the steel, galvanized, and aluminum subcategories. A brief summary of wastewater treatment methods is also given at the bottom of each plant day. Effluents were measured both at screening and at verification plants so data for every sampled plant is present. For simplicity, a total effluent has been derived by flow proportional summing of each of the effluent streams. If the effluent from a wastewater treatment system was from two lines running different basis materials, the effluent concentrations were presented as measured; in the case of multiple effluents, a flow proportional sum was arrived at by the concentrations. For the production normalized effluents, however, the production normalized discharge for dual line (treated) wastewater streams was flow apportioned between the two subcategories before presentation or, in the case of multiple effluents, summing. When non-contact cooling water or non-coil coating process water was added to an effluent, the concentration was not adjusted; however, the production normalized mass discharge was adjusted by subtracting a flow proportional mass.

The constituents in the final effluent streams are discussed in later sections.

The dcp effluent data were not useful because only a few facilities had effluent analyses and these were for a few metals only.

TABLE V-1

Listing of Visited Coil Coating Plants

Steel Subcategory		Galvanized Subcategory		Aluminum Subcategory	
Plant ID	Days Sampled	Plant ID	Days Sampled	Plant ID	Days Sampled
11055(s)	1	11058	2	1054	3
11058	2	12052	3	1057	3
12052	2	33056(s)	2	13029	3
36056	3	36058	1	15436(s)	3
36058	3	38053	3	40064	3
46050	2	46050	1		

(s) plants where screening was carried out

TABLE V-2

SCREENING AND VERIFICATION ANALYSIS TECHNIQUES

Pollutants	Screening Analysis Methodology	Verification Analysis Methodology
1. Acenaphthene	SP	
2. Acrolein	SP	
3. Acrylonitrile	SP	
4. Benzene	SP	
5. Benzidine	SP	
6. Carbon Tetrachloride (Tetrachloromethane)	SP	
7. Chlorobenzene	SP	
8. 1,2,4-Trichlorobenzene	SP	
9. Hexachlorobenzene	SP	
10. 1,2-Dichloroethane	SP	
11. 1,1,1-Trichloroethane	SP	
12. Hexachloroethane	SP	
13. 1,1-Dichloroethane	SP	VP: L-L Extract; GC,ECD
14. 1,1,2-Trichloroethane	SP	VP: L-L Extract; GC,ECD
15. 1,1,2,2-Tetrachloroethane	SP	
16. Chloroethane	SP	
17. Bis(Chloromethyl) Ether	SP	
18. Bis(2-Chloroethyl) Ether	SP	
19. 2-Chloroethyl Vinyl Ether (Mixed)	SP	
20. 2-Chloronaphthalene	SP	
21. 2,4,6-Trichlorophenol	SP	
22. Parachlorometa Cresol	SP	
23. Chloroform (Trichloromethane)	SP	
24. 2-Chlorophenol	SP	
25. 1,2-Dichlorobenzene	SP	
26. 1,3-Dichlorobenzene	SP	
27. 1,4-Dichlorobenzene	SP	
28. 3,3-Dichlorobenzidine	SP	
29. 1,1-Dichloroethylene	SP	
30. 1,2-Trans-Dichloroethylene	SP	VP: L-L Extract; GC,ECD

TABLE V-2 (CONTINUED)

SCREENING AND VERIFICATION ANALYSIS TECHNIQUES

Pollutants	Screening Analysis Methodology	Verification Analysis Methodology
31. 2,4-Dichlorophenol	SP	
32. 1,2-Dichloropropane	SP	
33. 1,2-Dichloropropylene (1,3-Dichloropropene)	SP	
34. 2,4-Dimethylphenol	SP	VP: GC - FID
35. 2,4-Dinitrotoluene	SP	
36. 2,6-Dinitrotoluene	SP	
37. 1,2-Diphenylhydrazine	SP	
38. Ethylbenzene	SP	
39. Fluoranthene	SP	SP
40. 4-Chlorophenyl Phenyl Ether	SP	
41. 4-Bromophenyl Phenyl Ether	SP	
42. Bis(2-Chloroisopropyl) Ether	SP	
43. Bis(2-Chloroethoxy) Methane	SP	
44. Methylene Chloride (Dichloromethane)	SP	
45. Methyl Chloride (Chloromethane)	SP	
46. Methyl Bromide (Bromomethane)	SP	
47. Bromoform (Tribromomethane)	SP	
48. Dichlorobromomethane	SP	
49. Trichlorofluoromethane	SP	
50. Dichlorodifluoromethane	SP	
51. Chlorodibromomethane	SP	
52. Hexachlorobutadiene	SP	
53. Hexachlorocyclopentadiene	SP	
54. Isophorone	SP	SP
55. Naphthalene	SP	SP
56. Nitrobenzene	SP	
57. 2-Nitrophenol	SP	
58. 4-Nitrophenol	SP	
59. 2,4-Dinitrophenol	SP	
60. 4,6-Dinitro-O-Cresol	SP	

TABLE V-2 (CONTINUED)

SCREENING AND VERIFICATION ANALYSIS TECHNIQUES

	Pollutants	Screening Analysis Methodology	Verification Analysis Methodology
61.	N-Nitrosodimethylamine	SP	
62.	N-Nitrosodiphenylamine	SP	
63.	N-Nitrosodi-N-Propylamine	SP	
64.	Pentachlorophenol	SP	
65.	Phenol	SP	VP: GC,ID
66.	Bis(2-Ethylhexyl) Phthalate	SP	SP
67.	Butyl Benzyl Phthalate	SP	SP
68.	Di-N-Butyl Phthalate	SP	SP
69.	Di-N-Octyl Phthalate	SP	SP
70.	Diethyl Phthalate	SP	SP
71.	Dimethyl Phthalate	SP	SP
72.	1,2-Benzanthracene (Benzo (a) Anthracene)	SP	SP
73.	Benzo (a) Pyrene (3,4-Benzo-Pyrene)	SP	SP
74.	3,4-Benzofluoranthene	SP	SP
75.	11,12-Benzofluoranthene (Benzo (k) Fluoranthene)	SP	SP
76.	Chrysene	SP	SP
77.	Acenaphthylene	SP	SP
78.	Anthracene	SP	SP
79.	1,12-Benzoperylene (Benzo (ghi)-Perylene)	SP	SP
80.	Fluorene	SP	SP
81.	Phenanthrene	SP	SP
82.	1,2,5,6-Dibenzathracene (Dibenzo (a,h) Anthracene)	SP	SP
83.	Indeno (1,2,3-cd) Pyrene (s,3-0-Phenylene Pyrene)	SP	SP
84.	Pyrene	SP	SP
85.	Tetrachloroethylene	SP	

TABLE V-2 (CONTINUED)

SCREENING AND VERIFICATION ANALYSIS TECHNIQUES

	Pollutants	Screening Analysis Methodology	Verification Analysis Methodology
86.	Toluene	SP	VP: L-L Extract; GC,FID
87.	Trichloroethylene	SP	VP: L-L Extract; GC,ECD
88.	Vinyl Chloride (Chloroethylene)	SP	
89.	Aldrin	SP	
90.	Dieldrin	SP	
91.	Chlordane (Technical Mixture and Metabolites)	SP	
92.	4,4-DDT	SP	
93.	4,4-DDE (p,p'-DDX)	SP	
94.	4,4-DDD (p,p'-TDE)	SP	
95.	Alpha-Endosulfan	SP	
96.	Beta-Endosulfan	SP	
97.	Endosulfan Sulfate	SP	
98.	Endrin	SP	
99.	Endrin Aldehyde	SP	
100.	Heptachlor	SP	
101.	Heptachlor Epoxide	SP	
	(BHC-Hexachlorocyclohexane)		
102.	Alpha-BHC	SP	
103.	Beta-BHC	SP	
104.	Gamma-BHC (Lindane)	SP	
105.	Delta-BHC	SP	
	(PCB-Polychlorinated Biphenyls)		
106.	PCB-1242 (Aroclor 1242)	SP	
107.	PCB-1254 (Aroclor 1254)	SP	
108.	PCB-1221 (Aroclor 1221)	SP	
109.	PCB-1232 (Aroclor 1232)	SP	
110.	PCB-1248 (Aroclor 1248)	SP	
111.	PCB-1260 (Aroclor 1260)	SP	
112.	PCB-1016 (Aroclor 1016)	SP	
113.	Toxaphene	SP	
114.	Antimony	SP	
115.	Arsenic	SP	

TABLE V-2 (CONTINUED)

SCREENING AND VERIFICATION ANALYSIS TECHNIQUES

	Pollutants	Screening Analysis Methodology	Verification Analysis Methodology
116.	Asbestos	--	
117.	Beryllium	ICAP	
118.	Cadmium	ICAP	40CFR 136: AA
119.	Chromium	ICAP	40CFR 136: AA
	Hexavalent Chromium	--	40CFR 136: Colorimetric
120.	Copper	ICAP	40CFR 136: AA
121.	Cyanide	40CRF 136: Dist./Col. Mea.	40CFR 136: Dist./Col. Mea.
	Cyanide Amenable to Chlorination		40CFR 136: Dist./Col. Mea.
122.	Lead	ICAP	40CFR 136: AA
123.	Mercury	SP	
124.	Nickel	SP	40CFR 136: AA
125.	Selenium	SP	
126.	Silver	SP	
127.	Thallium	SP	
128.	Zinc	ICAP	40CFR 136: AA
129.	2,3,4,8-Tetrachlorodibenzo-P-Dioxin (TCDD)	SP	
	Aluminum	—	40CFR 136: AA
	Flourides	—	Dist./I.E.
	Iron	—	40CFR 136: AA
	Manganese	—	40CFR 136: AA
	Phenols	--	40CFR 136
	Phosphorous Total	—	SM: Dig/SnCl
	Oil & Grease	—	40CFR 136: Dist./I.E.
	TSS	—	40CFR 136
	TDS	—	40CFR 136
	pH Minimum	—	Electrochemical
	pH Maximum	—	Electrochemical
	Temperature	—	—

TABLE V-2 (CONTINUED)

SCREENING AND VERIFICATION ANALYSIS TECHNIQUES

Notes

40CFR 136: Code of Federal Regulations, Title 40, Part 136.
SP - Sampling and Analysis Procedures for Screening of Industrial Effluents for Priority Pollutants, U.S. EPA, March, 1977, Revised April, 1977.
VP - Analytical Methods for the Verification Phase of BAT Review, U.S. EPA, June, 1977.
SM - Standard Methods, 14th Edition.
ICAP - Inductively Coupled Argon Plasma.
AA - Atomic Absorption.
L-L Extract; GC,ECD - Liquid-Liquid Extraction/Gas Chromatography, Electron Capture Detection.
Dig/$SnCl_2$ - Digestion/Stannous Chloride.
Filt./Grav. - Filtration/Gravimetric
Freon Ext. - Freon Extraction
Dist./Col. Mea. - Distillation/pyridine pyrazolone colorimetric
Dist./I.E. - Distillation/Ion Electrode
GC-FID - Gas Chromatography - Flame Ionization Detection.
SIE - Selective Ion Electrode

TABLE V-3

DCP PRIORITY POLLUTANT RESPONSES

Priority Pollutant	Known To Be Present	Believed To Be Present	Believed To Be Absent	Known To Be Absent	Screening Raw Waste Water Range (mg/l)
1. ancenaphthene	0	0	53	6	0.00
2. acrolein	0	0	53	8	0.00
3. acrylonitrile	0	0	51	8	0.00
4. benzene	0	0	52	8	*
5. benzidine	0	0	52	8	0.00
6. carbon tetrachloride (tetrachloromethane)	0	0	53	8	0.00
7. chlorobenzene	0	0	53	8	0.00
8. 1,2,4-trichlorobenzene	0	0	53	8	0.00
9. hexachlorobenzene	0	0	53	8	*
10. 1,2-dichloroethane	0	1	52	8	0.00
11. 1,1,1-trichloroethane	0	1	53	7	0.00
12. hexachloroethane	0	0	53	8	0.00
13. 1,1-dichloroethane	0	1	52	8	*
14. 1,1,2-trichloroethane	1	0	53	8	0.00
15. 1,1,2,2-tetrachloroethane	1	0	53	8	0.00
16. chloroethane	0	0	54	7	0.00
17. bis(chloromethyl) ether	0	0	53	8	0.00
18. bis(2-chloroethyl) ether	0	0	53	8	0.00
19. 2-chloroethyl vinyl ether (mixed)	0	0	53	8	0.00
20. 2-chloronaphthalene	0	0	53	8	0.00
21. 2,4,6-trichlorophenol	0	0	53	8	0.00
22. parachlorometa cresol	0	0	53	8	0.00
23. chloroform (trichloromethane)	0	0	53	8	*
24. 2-chlorophenol	0	0	54	7	0.00
25. 1,2-dichlorobenzene	0	0	53	8	0.00
26. 1,3-dichlorobenzene	0	0	53	8	0.00
27. 1,4-dichlorobenzene	0	0	53	8	0.00
28. 3,3-dichlorobenzidine	0	0	53	8	0.00

TABLE V-3 (CONTINUED)

DCP PRIORITY POLLUTANT RESPONSES

Priority Pollutant	Known To Be Present	Believed To Be Present	Believed To Be Absent	Known To Be Absent	Screening Raw Waste Water Range (mg/l)
29. 1,1-dichloroethylene	0	0	53	8	0.53
30. 1,2-trans-dichloroethylene	0	0	53	8	0.016
31. 2,4-dichlorophenol	0	0	53	8	0.00
32. 1,2-dichloropropane	0	0	53	8	0.00
33. 1,2-dichloropropylene (1,3-dichloropropene)	0	0	53	8	0.00
34. 2,4-dimethylphenol	0	0	54	7	0.021
35. 2,4-dinitrotoluene	0	0	53	8	0.00
36. 2,6-dinitrotoluene	0	0	53	8	0.00
37. 1,2-diphenylhydrazine	0	0	53	8	0.00
38. ethylbenzene	0	0	53	8	*
39. fluoranthene	0	0	53	8	*
40. 4-chlorophenyl phenyl ether	0	0	53	8	0.00
41. 4-bromophenyl phenyl ether	0	0	53	8	0.00
42. bis(2-chloroisopropyl) ether	0	0	53	8	0.00
43. bis(2-chloroethoxy) methane	0	0	53	8	0.00
44. methylene chloride (dichloromethane)	0	0	53	8	*
45. methyl chloride (chloromethane)	1	0	53	8	0.00
46. methyl bromide (bromomethane)	0	0	53	8	0.00
47. bromoform (tribromomethane)	0	0	53	8	*
48. dichlorobromomethane	0	0	53	8	0.00
49. trichlorofluoromethane	1	0	53	8	0.00
50. dichlorodifluoromethane	1	0	53	8	0.00
51. chlorodibromomethane	0	0	53	8	*
52. hexachlorobutadiene	0	0	53	8	0.00
53. hexachlorocyclopentadiene	0	0	53	8	0.00
54. isophorone	2	4	49	7	0.17 - 0.60
55. naphthalene	0	1	52	8	0.00

TABLE V-3 (CONTINUED)

DCP PRIORITY POLLUTANT RESPONSES

Priority Pollutant	Known To Be Present	Believed To Be Present	Believed To Be Absent	Known To Be Absent	Screening Raw Waste Water Range (mg/l)
56. nitrobenzene	0	0	53	8	0.00
57. 2-nitrophenol	0	0	53	8	0.00
58. 4-nitrophenol	0	0	53	8	0.00
59. 2,4-dinitrophenol	0	0	53	8	0.00
60. 4,6-dinitro-o-cresol	0	0	53	8	0.00
61. N-nitrosodimethylamine	0	0	53	8	0.00
62. N-nitrosodiphenylamine	0	0	53	8	0.00
63. N-nitrosodi-n-propylamine	0	0	53	8	0.00
64. pentachlorophenol	0	0	54	7	0.00
65. phenol	0	1	53	7	0.016
66. bis(2-ethylhezyl) phthalate	0	1	52	8	0.025 - 0.033
67. butyl benzyl phthalate	0	1	52	8	0.00
68. di-n-butyl phthalate	0	1	52	8	*
69. di-n-octyl phthalate	0	1	52	8	0.00
70. diethyl phthalate	0	1	52	8	*
71. dimethyl phthalate	0	1	52	8	*
72. 1,2-benzanthracene (benzo(a)anthracene)	0	0	53	8	0.00
73. benzo (a) pyrene (3,4-benzopyrene)	0	0	53	8	0.00
74. 3,4-benzofluoranthene (benzo(b)fluoranthene)	0	0	53	8	0.00
75. 11,12-benzofluoranthene (benzo(k)fluoranthene)	0	0	53	8	0.00
76. chrysene	0	0	53	8	*
77. ancenaphthylene	0	0	53	8	0.00
78. anthracene	0	0	53	8	0.064
79. 1,12-benzoperylene (benzo(ghi)perylene)	0	0	53	8	0.00
80. fluorene	1	0	52	8	0.00

TABLE V-3 (CONTINUED)

DCP PRIORITY POLLUTANT RESPONSES

Priority Pollutant	Known To Be Present	Believed To Be Present	Believed To Be Absent	Known To Be Absent	Screening Raw Waste Water Range (mg/l)
81. phenanthrene	0	0	53	8	0.064
82. 1,2,5,6-dibenzanthracene (dibenzo(a,h)anthracene)	0	0	53	8	0.00
83. indeno(1,2,3-cd)pyrene (2,3-o-phenylene pyrene)	0	0	53	8	0.00
84. pyrene	0	0	53	8	*
85. tetrachloroethylene	0	0	52	9	*
86. toluene	1	3	51	7	0.029
87. trichloroethylene	1	0	53	8	2.7
88. vinyl chloride (chloroethylene)	0	3	50	8	0.00
89. aldrin	0	0	53	8	0.00
90. dieldrin	0	0	53	8	0.00
91. chlordane (technical mixture and metabolites)	0	0	53	8	0.00
92. 4,4-DDT	0	0	53	8	0.00
93. 4,4-DDE (p,p-DDX)	0	0	53	8	0.00
94. 4,4-DDD (p,p-TDE)	0	0	53	8	0.00
95. alpha-endosulfan	0	0	53	8	0.00
96. beta-endosulfan	0	0	53	8	0.00
97. endosulfan sulfate	0	0	53	8	0.00
98. endrin	0	0	53	8	0.00
99. endrin aldehyde	0	0	53	8	0.00
100. heptachlor	0	0	53	8	0.00
101. heptachlor epoxide (BHC=hexachlorocyclohexane)	0	0	53	8	0.00
102. alpha-BHC	0	0	53	8	0.00
103. beta-BHC	0	0	53	8	0.00
104. gamma-BHC (lindane)	0	0	53	8	0.00

TABLE V-3 (CONTINUED)

DCP PRIORITY POLLUTANT RESPONSES

Priority Pollutant	Known To Be Present	Believed To Be Present	Believed To Be Absent	Known To Be Absent	Screening Raw Waste Water Range (mg/l)
105. delta-BHC (PCB=polychlorinated biphenyls)	1	0	53	7	0.00
106. PCB-1242 (Aroclor 1242)	1	0	53	7	0.00
107. PCB-1254 (Aroclor 1254)	1	0	53	7	0.00
108. PCB-1221 (Aroclor 1221)	0	0	54	7	0.00
109. PCB-1232 (Aroclor 1232)	0	0	54	7	0.00
110. PCB-1246 (Aroclor 1246)	0	0	54	7	0.00
111. PCB-1260 (Aroclor 1260)	0	0	54	7	0.00
112. PCB-1016 (Aroclor 1016)	0	0	54	7	0.00
113. Toxaphene	0	0	53	8	0.00
114. Antimony	0	6	47	8	1.3
115. Arsenic	0	0	52	9	0.075
116. Asbestos	0	1	52	8	--
117. Beryllium	0	1	52	8	0.00
118. Cadmium	3	8	39	9	≤0.002
119. Chromium	49	4	7	3	0.5 - 35.0
120. Copper	17	7	30	6	.060 - .066
121. Cyanide	20	5	30	7	0.07 - 17.5
122. Lead	19	6	31	7	0.20 - 1.46
123. Mercury	4	0	45	12	≤0.002
124. Nickel	11	8	34	8	0.0145
125. Selenium	2	1	47	11	0.00
126. Silver	0	2	48	11	0.02
127. Thallium	0	0	53	8	0.00
128. Zinc	26	5	23	7	0.20 - 337.0
129. 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)	1	1	49	9	0.00

-- No Analysis Performed
0.00 Not Detected
* Possibly Detected But ≤ 0.010 mg/l

TABLE V-4

SCREENING ANALYSIS RESULTS
(mg/l)

	Steel				Galvanized				Aluminum				
Parameter	Inlet	Raw Waste	Effluent	Blank	Inlet	Raw Waste	Effluent	Blank	Inlet	Raw Waste	Effluent	Quench	Blank
1 acenaphthene	0.00	0.00	0.00	–	0.00	0.00	0.00	–	0.00	0.00	–	0.00	–
2 acrolein	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	–	0.00	0.00
3 acrylonitrile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	–	0.00	0.00
4 benzene	0.00	*	*	0.00	*	*	*	*	0.00	*	–	0.00	0.00
5 benzidine	0.00	0.00	0.00	–	0.00	0.00	0.00	–	0.00	0.00	–	0.00	–
6 carbon tetrachloride	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	–	0.00	0.00
7 chlorobenzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	–	0.00	0.00
8 1,2,4-trichlorobenzene	0.00	0.00	0.00	–	0.00	0.00	0.00	–	0.00	0.00	–	0.00	–
9 hexachlorobenzene	0.00	0.00	0.00	–	0.00	0.00	0.00	–	0.00	0.00	–	0.00	–
10 1,2-dichloroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	–	0.00	0.00
11 1,1,1-trichloroethane	0.00	0.00	0.00	0.00	*	0.00	0.00	*	0.00	0.00	–	0.00	0.00
12 hexachloroethane	0.00	0.00	0.00	–	0.00	0.00	0.00	–	0.00	0.00	–	0.00	–
13 1,1-dichloroethane	0.00	0.00	0.00	0.00	0.00	*	*	0.00	0.00	0.00	–	0.00	0.00
14 1,1,2-trichloroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	–	0.00	0.00
15 1,1,2,2-tetrachloroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	–	0.00	0.00
16 chloroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	–	0.00	0.00
17 bis(chloromethyl)ether	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	–	0.00	0.00
18 bis(2-chloroethyl)ether	0.00	0.00	0.00	0.00	0.00	0.00	0.00	–	0.00	0.00	–	0.00	–
19 2-chloroethylvinylether	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	–	0.00	0.00
20 2-chloronaphthalene	0.00	0.00	0.00	–	0.00	0.00	0.00	–	0.00	0.00	–	0.00	–
21 2,4,6-trichlorophenol	0.00	0.00	0.00	–	0.00	0.00	0.00	–	0.00	0.00	–	0.00	–
22 parachlorometa cresol	0.00	0.00	0.00	–	0.00	0.00	0.00	–	0.00	0.00	–	0.00	–
23 chloroform	0.00	0.00	0.00	0.00	0.036	*	*	*	*	0.00	–	*	*
24 2-chlorophenol	0.00	0.00	0.00	–	0.00	0.00	0.00	–	0.00	0.00	–	0.00	–
25 1,2-dichlorobenzene	0.00	0.00	0.00	–	0.00	0.00	0.00	–	0.00	0.00	–	0.00	–
26 1,3-dichlorobenzene	0.00	0.00	0.00	–	0.00	0.00	0.00	–	0.00	0.00	–	0.00	–
27 1,4-dichlorobenzene	0.00	0.00	0.00	–	0.00	0.00	0.00	–	0.00	0.00	–	0.00	–
28 3,3-dichlorobenzene	0.00	0.00	0.00	–	0.00	0.00	0.00	–	0.00	0.00	–	0.00	–
29 1,1-dichloroethylene	0.00	0.00	0.00	0.00	0.00	0.530	0.070	0.00	0.00	0.00	–	0.00	0.00
30 1,2-trans-dichloroethylene	0.00	0.00	0.00	0.00	0.00	0.016	*	0.00	0.00	0.00	–	0.00	0.00
31 2,4-dichlorophenol	0.00	0.00	0.00	–	0.00	0.00	0.00	–	0.00	0.00	–	0.00	–
32 1,2-dichloropropane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	–	0.00	0.00
33 1,2-dichloropropylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	–	0.00	0.00

TABLE V-4 (CONTINUED)

SCREENING ANALYSIS RESULTS
(mg/1)

	Steel				Galvanized				Aluminum				
Parameter	Inlet	Raw Waste	Effluent	Blank	Inlet	Raw Waste	Effluent	Blank	Inlet	Raw Waste	Effluent	Quench	Blank
34 2,3-dimethylphenol	0.00	0.021	0.010	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
35 2,4-dinitrotoluene	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
36 2,6-dinitrotoluene	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
37 1,2-diphenolhydrazine	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
38 ethylbenzene	0.00	*	*	0.00	0.00	*	0.00	-	0.00	0.00	-	0.00	0.00
39 fluoranthene	0.00	*	*	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
40 4-chlorophenyl phenyl ether	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
41 4-bromophenyl phenyl ether	-	-	-	-	0.00	0.00	0.00	-	-	-	-	-	-
42 bis(2-chloroisopropyl)ether	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
43 bis(2-chloroethoxy)methane	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
44 methylene chloride	*	*	*	*	*	*	*	*	*	*	-	*	*
45 methyl chloride	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00
46 methyl bromide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00
47 bromoform	0.00	0.00	0.00	0.00	*	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00
48 dichlorobromomethane	0.00	0.00	0.00	0.00	0.029	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00
49 trichlorofluoromethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00
50 dichlorodifluoromethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00
51 chlorodibromomethane	0.00	0.00	0.00	0.00	0.022	*	*	0.00	0.00	0.00	-	0.00	0.00
52 hexachlorobutadiene	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
53 hexachlorocyclopentadiene	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
54 isophorone	0.00	0.60	0.56	-	0.00	0.17	0.11	-	0.00	0.00	-	0.00	-
55 naphthalene	0.00	0.00	*	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
56 nitrobenzene	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
57 2-nitrophenol	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
58 4-nitrophenol	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
59 2,4-dinitrophenol	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
60 4,6-dinitro-o-cresol	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
61 n-nitrosodimethylamine	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
62 n-nitrosodiphenylamine	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
63 n-nitrosodi-n-propylamine	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
64 pentachlorophenol	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
65 phenol	0.00	0.016	*	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
66 bis(2-ethylhexyl)phthalate	*	0.033	*	-	0.00	0.025	0.015	-	*	*	-	*	*

TABLE V-4 (CONTINUED)

SCREENING ANALYSIS RESULTS
(mg/l)

Parameter	Steel				Galvanized				Aluminum				
	Inlet	Raw Waste	Effluent	Blank	Inlet	Raw Waste	Effluent	Blank	Inlet	Raw Waste	Effluent	Quench	Blank
67 butyl benzyl phthalate	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	*	-
68 di-n-butyl phthalate	*	*	*	-	0.00	*	*	-	*	*	-	*	-
69 di-n-octyl phthalate	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	*	-
70 diethyl phthalate	*	*	*	-	*	*	0.00	-	0.018	0.00	-	*	-
71 dimethyl phthalate	0.00	0.00	0.00	-	0.00	*	*	-	0.00	0.00	-	0.00	-
72 1,2-benzathracene	0.00	*	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
73 benzo(a)pyrene	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
74 3,4-benzofluoranthene	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
75 11,12-benzo fluoranthene	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
76 chrysene	0.00	*	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
77 acenaphthylene	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
78 anthracene	0.00	0.064	*	-	0.00	*	*	-	0.00	0.00	-	0.00	-
79 1,12-benzoperylene	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
80 fluoreneathracene	0.00	0.00	*	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
81 phenanthrene	0.00	0.064	*	-	0.00	*	*	-	0.00	0.00	-	0.00	-
82 1,2,5,6-dibenzanthracene	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
83 indeno(1,2,3-cd) pyrene	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
84 pyrene	0.00	*	*	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
85 tetrachloroethylene	*	*	*	0.00	*	*	*	0.00	*	*	-	0.00	*
86 toluene	0.00	*	*	0.00	0.010	0.029	*	*	0.00	*	-	0.00	0.00
87 trichloroethylene	0.00	0.00	0.00	0.00	*	2.700	0.190	*	*	*	-	*	*
88 vinyl chloride	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00
89 aldrin	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
90 dieldrin	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
91 chlordane	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
92 4,4'-DDT	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
93 4,4-DDE (p,p'-DDX)	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
94 4,4'-DDD (p,p-TDE)	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
95 alpha-endosulfan	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
96 beta-endosulfan	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
97 endosulfan sulfate	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
98 endrin	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
99 endrin aldehyde	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-

TABLE V-4 (CONTINUED)

SCREENING ANALYSIS RESULTS
(mg/l)

Parameter	Steel Inlet	Steel Raw Waste	Steel Effluent	Steel Blank	Galvanized Inlet	Galvanized Raw Waste	Galvanized Effluent	Galvanized Blank	Aluminum Inlet	Aluminum Raw Waste	Aluminum Effluent	Aluminum Quench	Aluminum Blank
100 heptachlor	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
101 heptachlor epoxide	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
102 alpha-BHC	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
103 beta-BHC	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
104 gamma-BHC (Lindane)	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
105 delta-BHC	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
106 PCB-1242	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
107 PCB-1254	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
108 PCB-1221	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
109 PCB-1232	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
110 PCB-1248	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
111 PCB-1260	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
112 PCB-1016	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
113 toxaphene	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	-
114 antimony	0.00	1.30	0.00	-	0.00	0.00	0.150	-	0.00	0.00	0.00	0.00	-
115 arsenic	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	-
116 asbestos	-	-	-	-	-	-	-	-	-	-	-	-	-
117 beryllium	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001	-	<1.	<1.	<1.	0.00	-
118 cadmium	0.006	0.009	0.007	-	<0.002	0.008	<0.002	-	<2.	<2.	<2.	0.00	-
119 chromium (total)	0.034	35.000	0.122	-	0.007	0.500	0.500	-	0.010	20.000	0.040	0.040	-
120 copper	0.026	0.066	0.015	-	0.010	0.006	<0.006	-	0.040	0.060	0.050	0.050	-
121 cyanide (total)	<0.005	<0.005	<0.005	-	0.00	0.070	0.090	-	0.040	17.5	2.0	0.100	-
122 lead	<0.112	1.460	0.18	-	<0.020	0.200	<0.020	-	<0.020	0.200	<0.020	0.00	-
123 mercury	<0.0001	<0.0001	<0.0001	-	<0.0001	<0.0001	<0.0001	-	<0.0001	<0.0001	<0.0001	0.00	-
124 nickel	0.093	0.145	0.116	-	<0.005	<0.005	0.070	-	<5.	<5.	<5.	0.00	-
125 selenium	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	-
126 silver	0.018	0.020	0.021	-	<0.001	<0.001	<0.0001	-	<1.000	<1.000	<1.000	0.00	-
127 thallium	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	-
128 zinc	0.140	337.00	0.500	-	0.100	2.000	0.300	-	0.090	0.090	0.100	0.100	-
129 2,3,7,8-tetrachlorodibenzo-P-dioxin (TCDD)	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	-

TABLE V-4 (CONTINUED)

SCREENING ANALYSIS RESULTS
(mg/l)

Parameter	Steel				Galvanized				Aluminum				
	Inlet	Raw Waste	Effluent	Blank	Inlet	Raw Waste	Effluent	Blank	Inlet	Raw Waste	Effluent	Quench	Blank
aluminum	<0.05	1.94	<0.05	-	0.60	2.000	2.000	-	0.200	50.0	0.300	0.300	-
barium	0.019	0.527	0.018	-	0.01	0.010	<0.005	-	0.040	<0.005	0.010	0.010	-
borone	<0.05	0.246	0.053	-	-	-	-	-	0.10	9.0	0.100	0.100	-
calcium	66.0	70.2	348	-	46.0	28.00	30.0	-	59.0	50.0	60.0	-	-
chromium (hexavalent)	0.00	1.4	0.006	-	0.00	0.00	0.00	-	<0.005	<0.005	<0.005	0.00	-
cobalt	0.013	0.310	0.017	-	<0.005	0.50	0.200	-	<0.005	<0.005	<0.005	0.00	-
cyanide amendable to chlorination	<0.005	<0.005	<0.005	-	0.00	0.03	0.050	-	0.020	0.00	0.940	0.060	-
flourides	0.960	17.5	11.500	-	1.1	9.80	10.0	-	0.190	34.00	38.0	0.220	-
gold	-	-	-	-	0.00	0.00	0.0	-	0.00	0.042	0.00	0.00	-
iron	<0.17	15.4	<0.07	-	0.20	2.00	1.0	-	<0.2	3.00	<0.2	0.00	-
phenols (total)	0.013	0.027	0.027	-	0.006	0.005	<0.005	-	0.00	0.00	0.00	0.00	-
phosphorus	0.15	31.2	0.34	-	0.29	8.73	10.1	-	0.00	7.0	1.130	0.00	-
magnesium	21.40	21.400	3.500	-	20.0	13.00	14.00	-	13.0	20.0	13.0	13.00	-
manganese	0.011	0.454	<0.005	-	<0.005	0.050	0.070	-	0.01	0.4	0.020	0.020	-
molybdenum	0.016	0.066	0.033	-	<0.005	0.050	0.070	-	<0.005	0.05	<0.005	0.00	-
sodium	30.4	307	242	-	19.0	490	600	-	<15.	170	<15	0.00	-
strontium	0.033	0.327	0.033	-	-	-	-	-	-	-	-	-	-
tin	0.033	0.327	0.033	-	0.009	0.02	0.009	-	<0.050	0.060	<0.005	0.00	-
titanium	0.015	0.042	0.016	-	0.02	0.02	0.02	-	<0.020	<0.020	<0.020	0.00	-
vanadium	0.017	0.031	0.025	-	0.01	0.01	0.01	-	<0.010	<0.010	<0.010	0.00	-
yttrium	0.021	0.021	0.037	-	0.02	0.02	0.02	-	<0.020	<0.020	<0.010	0.00	-
oil and grease	513	207	6.0	-	0.00	-	18.0	-	0.00	170	5.0	4.0	-
total suspended solids	5	1,105	31.0	-	<5.0	34.00	6.0	-	0.00	806	158	2.8	-
total dissolved solids	546	1,650	3,145	-	-	-	-	-	202	910	1,050	228	-
minimum pH	7.5	6.5	8.0	-	8.2	8.0	7.5	-	4.5	6.0	6.0	3.0	-
maximum pH	7.7	9.0	9.8	-	8.3	9.9	7.5	-	7.0	6.7	9.0	7.4	-
temperature	20.3	33.0	29.5	-	26.0	28.0	28.0	-	13.4	28.7	31.9	13.0	-

- No Analysis Performed
0.00 Not Detected
* Possibly Detected But ≤ 0.010 mg/l

TABLE V-5
VERIFICATION PARAMETERS

	Aluminum Subcategory
39	fluoranthene
55	naphthalene
65	phenol
66	bis(2-ethylhexyl)phthalate
67	butyl benzyl phthalate
68	di-N-butyl phthalate
69	di-N-octyl phthalate
70	diethyl phthalate
71	dimethyl phthalate
72	1,2-benzanthracene
73	benzo(a)pyrene
74	3,4-benzofluoranthene
75	11,12-benzofluoranthene
76	chrysene
77	acenaphythylene
78	anthracene
79	benzo(ghi)perylene
80	fluorene
81	phenanthrene
82	dibenzo(a,h)anthracene
83	Ideno(1,2,3-cd)pyrene
84	pyrene
86	toluene
118	cadmium
119	chromium (total)
120	copper
121	cyanide (total)
122	lead
124	nickel
128	zinc
	aluminum
	iron
	manganese
	phenols (total)
	phosphorus
	oil and grease
	total suspended solids
	pH

	Steel Subcategory
11	1,1,1-trichloethane
13	1,1-dichloroethane
34	2,4-dimethylphenol
39	fluoranthene
54	isophorone
55	naphthalene
65	phenol
66	bis(2-ethylhexyl)phthalate
67	butyl benzyl phthalate
68	di-N-butyl phthalate
69	di-N-octyl phthalate
70	diethyl phthalate
71	dimethyl phthalate
72	1,2-benzanthracene
73	benzo(a)pyrene
74	3,4-benzofluoranthene
75	11,12-benzofluoranthene
76	chrysene
77	acenaphythylene
78	anthracene
79	benzo(ghi)perylene
80	fluorene
81	phenanthrene
82	dibenzo(a,h)anthracene
83	ideno(1,2,3-cd)pyrene
84	pyrene
86	toluene
87	trichloroethylene
118	cadmium
119	chromium (total)
120	copper
121	cyanide (total)
122	lead
124	nickel
128	zinc
	aluminum
	iron
	manganese
	phenols (total)
	phosphorous
	oil and grease
	total suspended solids
	pH

	Galvanized Subcategory
11	1,1,1-trichloethane
29	1,1-dichloroethylene
30	1,2-trans-dichloroethylene
39	fluoranthene
54	isophorone
55	naphthalene
65	phenol
66	bis(2-ethylhexyl)phthalate
67	butyl benzyl phthalate
68	di-N-butyl phthalate
69	di-N-octyl phthalate
70	diethyl phthalate
71	dimethyl phthalate
72	1,2-benzanthracene
73	benzo(a)pyrene
74	3,4-benzofluoranthene
75	11,12-benzofluoranthene
76	chrysene
77	acenaphthalene
78	anthracene
79	benzo(ghi)perylene
80	fluorene
81	phenanthrene
82	dibenzo(a,h)anthracene
83	ideno(1,2,3-cd)pyrene
84	pyrene
86	toluene
87	trichloroethylene
118	cadmium
119	chromium (total)
120	copper
121	cyanide (total)
122	lead
124	nickel
128	zinc
	aluminum
	iron
	manganese
	phenols (total)
	phosphorous
	oil and grease
	total suspended solids
	pH

TABLE V-6

DCP DATA, STEEL SUBCATEGORY

PLANT ID	OTHER SUBCATEGORIES	AREA CLEANED $(10^3 m^2)$	AREA CONVERSION COATED $(10^3 m^2)$	AREA PAINTED $(10^3 m^2)$	PRODUCTION CAPACITY m^2/hr	AVERAGE 1976 PRODUCTION m^2/hr	PROCESS WATER RATE l/hr	WATER USE l/m^2
41074	A	20	20	20	640	3	5	0.833
11104	A	10	10	10	330	20	110	2.750
41064	G,A	240	240	350	1,670	40	350	4.375
36037	A	280	280	280	540	50	310	3.100
11080	A	1,560	1,560	1,560	1,440	220	2,730	6.205
36051	A	2,790	2,790	2,790	830	230	310	0.674
47031	G	2,720	2,720	2,310	4,830	280	2,230	3.982
38053	G	3,060	3,060	6,120	8,780	330	400	0.606
36073	G,A	870	810	870	1,070	370	1,910	2.581
20058	—	6,880	6,500	6,690	850	510	4,320	4.235
04105	G,A	2,970	2,970	2,970	9,480	680	160	0.118
33056	G,A	3,340	3,340	3,340	4,740	680	5,470	4.022
46050	G	12,760	12,760	12,760	2,790	1,020	6,240	3.059
36074	G,A	7,900	7,900	7,900	2,790	1,160	2,930	1.263
04091	A	4,700	4,700	4,700	10,030	1,400	1,250	0.446
36088	G	17,550	17,550	17,550	4,460	1,570	10,570	3.366
36056	G	11,150	11,150	11,150	7,520	1,630	1,090	0.334
11079	G	14,670	14,670	14,670	6,170	1,670	3,300	0.988
06092	—	690	690	23,820	2,400	1,820	7,950	2.184
33192	A	13,040	13,040	13,340	5,570	1,860	9,310	2.503
33267	—	13,680	13,680	24,620	5,760	1,860	34,070	9.16
28043	—	23,670	23,670	23,670	3,080	1,880	850	0.226
04104	—	15,790	430	29,730	3,250	1,890	25,440	6.73
09034	G,A	10,180	10,180	10,180	8,360	2,070	13,200	3.188
18053	G	8,220	6,180	10,260	7,800	2,090	2,300	0.550
36058	G,A	18,640	18,640	20,960	11,610	2,140	85,660	20.01
11051	G	3,340	3,340	3,340	5,760	2,320	100	0.022
20053	G,A	3,130	3,130	3,210	3,960	2,800	1,270	0.227
01055	—	31,490	31,490	62,860	4,010	2,990	11,360	1.900
47030	—	330	330	NA	2,840	3,090	4,540	0.735
33047	A	29,540	28,150	28,980	7,800	3,460	5,020	0.725
36054	G,A	12,650	10,280	12,970	10,870	4,690	14,810	1.579
33263	—	29,690	NA	33,540	11,150	5,530	3,240	0.293
18050	A	32,830	32,830	35,370	12,480	6,460	39,660	3.070
12052	—	86,210	43,110	43,110	15,330	9,810	5,680	0.290

TABLE V-7

DCP DATA, GALVANIZED SUBCATEGORY

PLANT ID	OTHER SUBCATEGORIES	AREA CLEANED (10^3 m^2)	AREA CONVERSION COATED (10^3 m^2)	AREA PAINTED (10^3 m^2)	PRODUCTION CAPACITY m^2/hr	AVERAGE 1976 PRODUCTION m^2/hr	PROCESS WATER RATE l/hr	WATER USE l/m^2
41064	S,A	390	390	780	1,670	60	510	4.250
09034	S,A	600	600	1,200	8,360	120	680	2.833
36074	S,A	970	970	970	2,790	140	310	1.107
36073	S,A	400	400	810	1,070	310	770	1.242
36088	S	4,390	4,390	4,390	4,460	390	2,300	2.949
04105	S,A	2,230	2,230	2,230	9,480	510	100	0.098
36058	S,A	4,680	4,680	8,440	11,610	540	18,810	17.42
33056	S,A	4,320	4,320	4,320	4,740	870	6,190	3.557
46050	S	11,250	11,250	11,250	2,790	900	5,110	2.839
11079	S	6,320	6,320	12,080	4,050	1,140	1,240	0.554
47031	S	17,170	17,170	34,340	4,830	1,550	12,250	3.952
36056	S	11,150	11,150	18,580	7,520	1,630	950	0.291
18053	S	8,220	6,180	10,260	7,800	2,090	2,010	0.481
11051	S	30,280	30,280	45,430	5,760	2,370	810	0.171
38053	S	22,260	22,260	44,510	8,780	2,380	2,550	0.536
20053	S,A	2,620	2,620	3,800	3,960	2,800	930	0.166
36054	S,A	8,960	7,280	9,190	9,200	3,320	9,160	1.380
23034	—	70,730	70,730	130,150	12,260	8,060	50,800	3.151

TABLE V-8
DCP DATA, ALUMINUM SUBCATEGORY

PLANT ID	OTHER SUBCATEGORIES	AREA CLEANED $(10^3\ m^2)$	AREA CONVERSION COATED $(10^3\ m^2)$	AREA PAINTED $(10^3\ m^2)$	PRODUCTION CAPACITY m^2/hr	AVERAGE 1976 PRODUCTION m^2/hr	PROCESS WATER RATE 1/hr	WATER USE 1/m
36058	S,G	20	20	30	11,610	2	80	20.00
18050	S	30	30	60	4,030	10	20	1.000
36074	S,G	210	210	210	2,790	30	60	1.000
33056	S,G	220	220	220	4,740	40	300	3.750
33047	S	1,490	1,490	1,490	7,800	170	200	0.588
36051	S	2,790	2,790	2,790	280	230	250	0.543
09034	S,G	1,200	1,200	1,200	8,360	240	1,260	2.625
11104	S	110	110	110	330	250	1,030	2.060
36073	S,G	20	20	50	1,070	330	50	0.076
41074	S	2,540	2,540	1,690	640	360	450	0.625
36037	S	1,980	1,980	1,980	540	380	1,960	2.579
28039	—	31,090	31,090	46,600	4,520	440	870	0.989
36054	S,G	1,540	1,540	1,590	5,020	570	1,460	1.281
11080	S	4,940	4,940	4,940	1,440	700	7,030	5.021
41064	S,G	4,920	4,920	5,410	1,670	800	5,970	3.731
33387	—	14,400	14,400	14,400	2,230	1,000	3,860	1.930
20050	—	8,850	8,850	12,270	1,340	1,090	7,920	3.633
33046	—	5,110	5,110	4,620	11,150	1,350	26,120	9.67
04091	S	4,700	4,700	4,700	10,030	1,400	1,020	0.364
01054	—	16,780	16,780	16,780	5,950	1,430	2,680	0.937
04088	—	5,840	5,840	9,940	1,670	1,430	3,410	1.192
33087	—	18,740	18,740	18,740	3,010	1,630	10,290	3.156
11477	—	21,370	18,580	12,080	2,790	1,810	30,660	8.470
04089	—	13,660	13,660	13,660	3,760	1,860	5,110	1.374
40836	—	11,750	11,700	11,700	3,400	1,880	4,820	1.282
04105	S,G	8,360	8,360	8,360	9,480	1,920	370	0.096
33192	S	28,990	28,990	28,990	6,690	1,930	16,800	4.352
40064	—	27,370	27,370	15,570	6,620	2,190	9,990	2.281
46030	—	15,050	15,050	18,580	9,540	2,430	122,630	25.23
20049	—	11,730	11,730	17,000	4,280	2,440	13,630	2.793
36038	—	24,150	24,150	13,280	8,360	3,020	3,070	0.508
15187	—	36,420	36,420	36,420	6,130	3,070	71,920	11.71
20053	S,G	46,440	46,440	48,760	6,160	3,930	15,300	1.947
33080	—	19,940	19,880	19,880	2,170	4,790	9,080	0.948
15436	—	16,190	16,190	25,900	8,360	5,210	5,000	0.480
11076	—	30,660	30,660	30,660	5,850	5,390	23,260	2.158
33082	—	53,140	53,140	61,310	12,360	5,740	12,490	1.088
01058	—	27,870	27,870	13,940	17,560	7,020	36,340	2.588
45476	—	118,910	29,820	29,450	27,380	8,500	36,340	2.138
12034	--	353,020	353,020	103,490	16,720	9,200	7,080	0.385
01390	—	199,740	199,740	199,740	27,590	13,800	18,170	1.317

TABLE V-9

VISITED PLANT WATER USE, STEEL SUBCATEGORY

Plant ID (Day)	Area Processed (Both Sides) m^2/Day	Cleaning Water 1/Day	Conversion Coating Water 1/Day	Quench Water 1/Day	Total Water 1/Day	Cleaning Water Use 1/m^2	Conversion Coating Water Use 1/m^2	Quench Water Use 1/m^2	Total Water Use 1/m^2
11058 (1)	4,820	7,720	1,360		9,080	1.602	0.282		1.884
11058 (2)	7,360	10,840	3,210		14,050	0.147	0.436		1.909
36058 (4)	44,550	327,020	1,820	254,350	583,190	7.34	0.041	5.71	13.09
11055 (1)	48,350				73,210				1.514
12052 (2)	92,360	130,810	65,410	693,200	889,420	1.416	0.708	7.51	9.63
46050 (1)	99,440	156,970	75,500	510,160	742,630	1.579	0.759	5.130	7.468
36056 (3)	106,390				70,860				0.666
36056 (1)	110,770	32,700	38,150		70,860	0.295	0.344		0.640
36058 (3)	129,260	654,050		218,020	872,060	5.06		1.687	6.75
36058 (1)	162,140				872,060				5.38
12052 (3)	173,340	130,810	65,410	693,200	889,420	0.755	0.377	3.999	5.13
36056 (2)	193,030				70,860				0.367

TABLE V-10

VISITED PLANT WATER USE, GALVANIZED SUBCATEGORY

Plant ID (Day)	Area Processed (Both Sides) m²/Day	Cleaning Water 1/Day	Conversion Coating Water 1/Day	Quench Water 1/Day	Total Water 1/Day	Cleaning Water Use 1/m²	Conversion Coating Water Use 1/m²	Quench Water Use 1/m²	Total Water Use 1/m²
46050 (2)	38,370	102,650	48,690	227,890	379,230	2.675	1.269	5.94	9.88
11058 (1)	49,310				92,020				1.866
12052 (3)	62,230	61,770	52,320	408,780	522,880	0.993	0.841	6.57	8.40
46050 (3)	63,510	153,970	75,490	510,160	739,620	2.424	1.187	8.03	11.65
11058 (2)	73,240				149,280				2.038
36058 (2)	73,760	327,020	1,820	254,350	583,190	4.434	0.025	3.448	7.91
12052 (1)	80,690	90,660	52,320	408,708	551,760	1.124	0.648	5.07	6.84
12052 (2)	86,270	64,950	52,320	408,780	526,055	0.735	0.606	4.738	6.10
33056 (1)	89,980	14,940	51,780	39,240	106,010	0.167	0.575	0.436	1.178
33056 (2)	89,980	17,710	38,240	39,240	95,200	0.197	0.425	0.456	1.058
38053 (3)	101,130	89,020	9,920		98,940	0.880	0.096		0.978
38053 (2)	109,470	87,740	9,540		97,280	0.801	0.087		0.889
38053 (1)	147,220	87,590	7,340		94,930	0.595	0.050		0.645

TABLE V-11

VISITED PLANT WATER USE, ALUMINUM SUBCATEGORY

Plant ID (Day)	Area Processed (Both Sides) m^2/Day	Cleaning Water 1/Day	Conversion Coating Water 1/Day	Quench Water 1/Day	Total Water 1/Day	Cleaning Water Use $1/m^2$	Conversion Coating Water Use $1/m^2$	Quench Water Use $1/m^2$	Total Water Use $1/m^2$
13029 (1)	35,020	32,980	61,320	109,010	203,300	0.942	1.751	3.113	5.81
15436 (3)	52,060				65,010				1.249
15436 (2)	53,800				65,010				1.208
01054 (2)	72,200	14,640	11,620		26,260	0.203	0.161		0.364
01057 (2)	74,310	142,980	60,500	261,620	465,100	1.924	0.814	3.521	6.26
15456 (1)	75,840				66,770				0.880
01057 (3)	83,200	163,510	42,240	261,570	467,320	1.965	0.508	3.144	5.62
01057 (1)	85,980	163,510	43,690	261,620	468,830	1.902	0.508	3.043	5.45
01054 (1)	86,360	20,530	18,440		38,970	0.238	0.214		0.451
13029 (2)	87,900	54,870	48,780	109,010	212,660	0.624	0.555	1.240	2.419
13029 (3)	88,030	43,150	57,140	109,010	209,300	0.490	0.649	1.238	2.378
40064 (2)	114,010	114,460	47,150	198,400	360,000	1.004	0.414	1.740	3.158
40064 (1)	114,010	117,730	48,600	228,920	395,250	1.033	0.426	2.008	3.467
40064 (3)	114,010	122,630	47,960	245,270	415,870	1.076	0.421	2.151	3.648
01054 (3)	135,450	22,170	18,530		40,700	0.164	0.137		0.300

TABLE V-12

SUMMARY OF WATER USE
$(1/m^2)$

FUNCTIONAL OPERATION	BASIS MATERIAL	MINIMUM	MAXIMUM	MEAN	MEDIAN	# POINTS
VISITED PLANTS						
Cleaning	Steel	0.147	7.34	2.274	1.498	8
	Galvanized	0.167	4.434	1.368	0.880	11
	Aluminum	0.164	1.965	0.964	0.973	12
Conversion Coating	Steel	0.041	0.759	0.421	0.377	7
	Galvanized	0.025	1.269	0.528	0.575	11
	Aluminum	0.137	1.751	0.546	0.467	12
Painting (Quench)	All Basis Material	0.436	8.03	3.632	3.296	22
All Operations	Steel	0.624	16.13	6.33	5.17	
	Galvanized	0.628	13.73	5.53	4.75	
	Aluminum	0.737	11.75	5.14	4.736	
DCP RESPONSES						
All Operations	Steel	0.022	20.01	2.752	1.900	35
	Galvanized	0.098	17.42	2.610	1.311	18
	Aluminum	0.076	25.23	3.363	1.930	41

Minimum - the lowest value found in the analysis of each appropriate waste stream.
Maximum - the highest value found in the analysis of each appropriate waste stream.
Mean - the average value calculated from the analysis data from each appropriate waste stream.
Median - the central value selected from ranking appropriate stream values.
Points - the number of streams with a reported value for the specific parameter.

TABLE V-13

SUMMARY OF VISITED PLANTS PROCESS LINES
PROCESS LINE

	Metal Processed	Clean # 1	No. of Rinses	Clean # 2	No. of Rinses	Conversion Coat	No. of Rinses	Sealing or Acidulated Rinse	Roll Coat and Oven Cure	Quench	Roll Coat and Oven Cure	Quench
01057	A	Alkaline	2	-	-	Chromate	1	Yes	Two	Water	One	Water
11055	S	Alkaline	2	-	-	Iron Phosphate	2	Yes	Two Sides	Water	One Side	Water
11058 Line 1	S	Alkaline	3	-	-	Iron Phosphate	3	No	One Side	Water	One Side	Water
11058 Line 2	G	Alkaline	3	-	-	Complex Oxides	3	No	Two	Water	One	Water
12052 Line #1	G	Alkaline	2	-	-	Spray	2	Yes		Water		Water
12052 Line #2	G on day 1,S on Day 2,3	Alkaline	1	Alkaline	1	Dip	1	Yes		Water		Water
15436	A	Alkaline	0	Alkaline	2	Chromate	2	No	Two Sides	Water	One Side	Water
33056	A	Alkaline	1	-	-	Chromate	1	Yes	Two	Water	One	Water
36056	S	Alkaline	1	-	-	Iron Phosphate	1	Yes	Two Sides	Water	Two Sides	Water
40064	A	Alkaline	1	-	-	Chromate	1	Yes	Two Sides	Water	One Side (sometimes)	Water
46050	S, G	Alkaline	1	Alkaline	2	Zinc Phosphate	1	Yes	Two Sides	Water	-	-

TABLE V-14
CLEANING RAW WASTEWATER POLLUTANTS (mg/l)
STEEL SUBCATEGORY

	PARAMETER	MINIMUM	MAXIMUM	MEAN	MEDIAN	# PTS	# ZEROS
	Flow Liters/Day	7720	654,050	181,370	130,810	8	0
11	1,1,1-Trichloroethane	*	*	*	*	5	1
13	1,1-Dichloroethane	0.00	0.00	0.00	0.00	0	5
29	1,1-Dichloroethylene	0.00	0.00	0.00	0.00	0	2
30	1,2-Trans-Dichloroethylene	0.00	0.00	0.00	0.00	0	2
34	2,4-Dimethylphenol	0.00	0.00	0.00	0.00	0	3
39	Fluoranthene	0.068	0.068	0.068	0.068	1	8
54	Isophorone	0.018	0.018	0.018	0.018	1	8
55	Naphthalene	*	0.020	0.010	0.010	2	7
65	Phenol	0.00	0.00	0.00	0.00	0	3
66	Bis(2-ethyhexl)phthalate	*	0.154	0.044	0.020	7	2
67	Butyl benzyl phthalate	0.358	0.358	0.358	0.358	1	8
68	Di-N-Butyl phthalate	*	0.030	0.009	*	5	4
69	Di-N-Octyl phthalate	*	*	*	*	3	6
70	Diethyl phthalate	*	0.207	0.069	0.030	6	3
71	Dimethyl phthalate	0.00	0.00	0.00	0.00	0	9
72	1,2-Benzanthracene	*	0.030	0.015	0.015	2	7
73	Benzo(A)pyrene	0.00	0.00	0.00	0.00	0	9
74	3,4-Benzofluoranthene	0.00	0.00	0.00	0.00	0	9
75	Benzo(K)fluoranthene	0.0	0.00	0.00	0.00	0	9
76	Chrysene	*	0.030	0.015	0.015	2	7
77	Acenaphthylene	*	*	*	*	1	8
78	Anthracene	*	0.280	0.065	*	7	2
79	1,1,2-Benzoperylene	0.00	0.00	0.00	0.00	0	9
80	Fluorene	*	*	*	*	1	8
81	Phenanthrene	*	0.280	0.065	*	7	2
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0	9
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0	9
84	Pyrene	0.00	0.00	0.00	0.00	0	9
86	Toluene	0.00	0.00	0.00	0.00	0	3
87	Trichloroethylene	*	0.022	0.006	*	4	2
118	Cadmium	0.003	0.006	0.005	0.005	2	7
119	Chromium, Total	0.028	0.620	0.244	0.183	8	1
	Chromium, Hexavalent	0.00	0.00	0.00	0.00	0	9
120	Copper	0.021	0.180	0.070	0.059	9	0
121	Cyanide, Total	0.009	0.120	0.044	0.024	5	3
	Cyanide Amn. to Chlor.	0.011	0.099	0.046	0.028	3	5
122	Lead	0.180	1.050	0.536	0.458	4	5
124	Nickel	0.004	0.210	0.069	0.039	5	4
128	Zinc	0.220	43.300	10.436	3.200	9	0
	Aluminum	0.270	0.848	0.454	0.340	7	2
	Fluorides	0.180	3.400	1.285	0.980	9	0
	Iron	0.930	80.000	24.911	5.200	9	0
	Manganese	0.260	1.650	0.797	0.630	9	0
	Phenols, Total	0.019	0.270	0.112	0.020	5	3
	Phosphorus	11.400	77.893	45.670	42.300	7	0
	Oil and Grease	9.800	1688.999	522.618	261.000	9	0
	Total Dissolved Solids	1124.000	17199.997	9251.496	9340.996	4	0
	Total Suspended Solids	51.600	440.000	220.761	256.000	9	0
	Minimum pH	6.8	10.9	8.7	8.5	9	0
	Maximum pH	7.4	11.9	10.0	10.6	9	0
	Temperature Deg C	23.0	56.8	29.6	37.7	9	0

* - Possibly detected but $\leq$ 0.010 mg/l

TABLE V-15
CLEANING RAW WASTEWATER POLLUTANTS (mg/m^2)
STEEL SUBCATEGORY

	PARAMETER	MINIMUM	MAXIMUM	MEAN	MEDIAN	# PTS	# ZEROS
	Flow Liters/m^2	0.147	7.34	2.274	1.498	8	0
11	1,1,1-Trichloroethane	*	*	*	*	5	1
13	1,1-Dichloroethane	0.00	0.00	0.00	0.00	0	5
29	1,1-Dichloroethylene	0.00	0.00	0.00	0.00	0	2
30	1,2-Trans-Dichloroethylene	0.00	0.00	0.00	0.00	0	2
34	2,4-Dimethylphenol	0.00	0.00	0.00	0.00	0	3
39	Fluoranthene	0.109	0.109	0.109	0.109	1	8
54	Isophorone	0.132	0.132	0.132	0.132	1	8
55	Naphthalene	0.037	0.101	0.069	0.069	2	7
65	Phenol	0.00	0.00	0.00	0.00	0	3
66	Bis(2-ethyhexl)phthalate	*	0.779	0.137	0.033	7	2
67	Butyl benzyl phthalate	0.574	0.574	0.574	0.574	1	8
68	Di-N-Butyl phthalate	*	0.071	0.019	*	5	4
69	Di-N-Octyl phthalate	*	0.025	0.008	*	3	6
70	Diethyl phthalate	*	0.327	0.087	0.042	6	3
71	Dimethyl phthalate	0.00	0.00	0.00	0.00	0	9
72	1,2-Benzanthracene	*	0.044	0.022	0.022	2	7
73	Benzo(A)pyrene	0.00	0.00	0.00	0.00	0	9
74	3,4-Benzofluoranthene	0.00	0.00	0.00	0.00	0	9
75	Benzo(K)fluoranthene	0.0	0.00	0.00	0.00	0	9
76	Chrysene	*	0.044	0.022	0.022	2	7
77	Acenaphthylene	*	*	*	*	1	8
78	Anthracene	*	0.449	0.101	*	7	2
79	1,1,2-Benzoperylene	0.00	0.00	0.00	0.00	0	9
80	Fluorene	*	*	*	*	1	8
81	Phenanthrene	*	0.449	0.101	*	7	2
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0	9
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0	9
84	Pyrene	0.00	0.00	0.00	0.00	0	9
86	Toluene	0.00	0.00	0.00	0.00	0	3
87	Trichloroethylene	*	0.035	0.009	*	4	2
118	Cadmium	0.002	0.008	0.005	0.005	2	7
119	Chromium, Total	0.044	0.878	0.349	0.330	8	1
	Chromium, Hexavalent	0.00	0.00	0.00	0.00	0	9
120	Copper	0.021	0.911	0.177	0.090	9	0
121	Cyanide, Total	0.012	0.170	0.070	0.066	5	3
	Cyanide Amn. to Chlor.	0.011	0.140	0.065	0.044	3	5
122	Lead	0.152	1.487	0.530	0.241	4	5
124	Nickel	0.001	0.324	0.123	0.062	5	4
128	Zinc	0.324	59.908	14.131	3.185	9	0
	Aluminum	0.204	2.732	1.062	0.513	7	2
	Fluorides	0.072	5.009	2.066	1.388	9	0
	Iron	1.125	113.302	38.311	38.169	9	0
	Manganese	0.172	3.694	1.489	1.245	9	0
	Phenols, Total	0.030	0.398	0.209	0.147	5	3
	Phosphorus	14.333	214.033	78.304	50.860	7	0
	Oil and Grease	9.754	4477.992	1153.777	312.963	9	0
	Total Dissolved Solids	8250.359	26934.605	17511.984	17431.512	4	0
	Total Suspended Solids	51.359	1879.087	463.865	230.909	9	0
	Minimum pH	6.8	10.9	8.8	8.5	9	0
	Maximum pH	7.4	11.9	10.0	10.6	9	0
	Temperature Deg C	23.0	56.8	29.6	37.7	9	0

* - Possibly detected but ≤ 0.010 mg/l

TABLE V-16
CONVERSION COATING RAW WASTEWATER POLLUTANTS (mg/l)
STEEL SUBCATEGORY

	PARAMETER	MINIMUM	MAXIMUM	MEAN	MEDIAN	# PTS	# ZEROS
	Flow Liters/Day	1360	75,500	35,840	38,150	8	0
11	1,1,1-Trichloroethane	*	0.043	0.014	*	3	5
13	1,1-Dichloroethane	0.077	0.077	0.077	0.077	1	6
29	1,1-Dichloroethylene	0.00	0.00	0.00	0.00	0	2
30	1,2-Trans-Dichloroethylene	0.00	0.00	0.00	0.00	0	2
34	2,4-Dimethylphenol	0.00	0.00	0.00	0.00	0	3
39	Fluoranthene	*	*	*	*	1	6
54	Isophorone	0.00	0.00	0.00	0.00	0	7
55	Naphthalene	*	*	*	*	4	3
65	Phenol	0.00	0.00	0.00	0.00	0	3
66	Bis(2-ethyhexl)phthalate	*	0.110	0.028	0.014	5	2
67	Butyl benzyl phthalate	0.00	0.00	0.00	0.00	0	7
68	Di-N-Butyl phthalate	*	0.014	0.005	*	3	4
69	Di-N-Octyl phthalate	0.760	0.760	0.760	0.760	1	6
70	Diethyl phthalate	*	0.184	0.121	0.135	6	1
71	Dimethyl phthalate	0.00	0.00	0.00	0.00	0	7
72	1,2-Benzanthracene	0.00	0.00	0.00	0.00	0	7
73	Benzo(A)pyrene	0.00	0.00	0.00	0.00	0	7
74	3,4-Benzofluoranthene	0.00	0.00	0.00	0.00	0	7
75	Benzo(K)fluoranthene	0.00	0.00	0.00	0.00	0	7
76	Chrysene	0.00	0.00	0.00	0.00	0	7
77	Acenaphthylene	*	*	*	*	1	6
78	Anthracene	*	*	*	*	3	4
79	1,1,2-Benzoperylene	0.00	0.00	0.00	0.00	0	7
80	Fluorene	*	*	*	*	2	5
81	Phenanthrene	*	*	*	*	3	4
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0	7
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0	7
84	Pyrene	0.00	0.00	0.00	0.00	0	7
86	Toluene	0.00	0.00	0.00	0.00	0	3
87	Trichloroethylene	*	0.089	0.034	0.014	3	5
118	Cadmium	0.001	0.073	0.027	0.006	3	5
119	Chromium, Total	0.280	920.000	320.216	71.081	8	0
	Chromium, Hexavalent	0.060	408.000	129.035	42.888	7	1
120	Copper	0.029	0.161	0.054	0.032	6	2
121	Cyanide, Total	0.092	0.092	0.092	0.092	1	6
	Cyanide Amn. to Chlor.	0.012	0.012	0.012	0.012	1	6
122	Lead	0.010	3.600	1.363	0.480	3	5
124	Nickel	0.120	18.873	8.130	6.762	4	4
128	Zinc	0.530	143.000	54.128	51.264	8	0
	Aluminum	0.199	10.600	3.030	1.190	5	3
	Fluorides	1.100	74.000	30.953	27.428	8	0
	Iron	3.251	77.000	19.140	9.234	8	0
	Manganese	0.110	1.510	0.612	0.485	8	0
	Phenols, Total	≤0.005	0.230	0.067	0.019	4	3
	Phosphorus	9.680	70.500	40.730	43.400	6	0
	Oil and Grease	2.000	18.400	7.618	6.600	6	1
	Total Dissolved Solids	3282.000	3500.000	3390.664	3389.998	3	0
	Total Suspended Solids	26.603	248.000	126.827	133.500	8	0
	Minimum pH	3.3	11.4	5.8	4.3	8	0
	Maximum pH	5.1	11.5	7.7	7.5	8	0
	Temperature Deg C	20.0	53.7	36.5	41.2	8	0

* - Possibly detected but ≤ 0.010 mg/l

TABLE V-17
CONVERSION COATING RAW WASTEWATER POLLUTANTS (mg/m^2)
STEEL SUBCATEGORY

	PARAMETER	MINIMUM	MAXIMUM	MEAN	MEDIAN	# PTS	# ZEROS
	Flow Liters/m^2	0.041	0.759	0.421	0.377	7	0
11	1,1,1-Trichloroethane	*	0.021	0.007	*	3	5
13	1,1-Dichloroethane	0.034	0.034	0.034	0.034	1	6
29	1,1-Dichloroethylene	0.00	0.00	0.00	0.00	0	2
30	1,2-Trans-Dichloroethylene	0.00	0.00	0.00	0.00	0	2
34	2,4-Dimethylphenol	0.00	0.00	0.00	0.00	0	3
39	Fluoranthene	*	*	*	*	1	6
54	Isophorone	0.00	0.00	0.00	0.00	0	7
55	Naphthalene	*	*	*	*	4	3
65	Phenol	0.00	0.00	0.00	0.00	0	3
66	Bis(2-ethyhexl)phthalate	*	0.053	0.011	*	5	2
67	Butyl benzyl phthalate	0.00	0.00	0.00	0.00	0	7
68	Di-N-Butyl phthalate	*	*	*	*	3	4
69	Di-N-Octyl phthalate	0.332	0.332	0.332	0.332	1	6
70	Diethyl phthalate	*	0.139	0.067	0.069	6	1
71	Dimethyl phthalate	0.00	0.00	0.00	0.00	0	7
72	1,2-Benzanthracene	0.00	0.00	0.00	0.00	0	7
73	Benzo(A)pyrene	0.00	0.00	0.00	0.00	0	7
74	3,4-Benzofluoranthene	0.00	0.00	0.00	0.00	0	7
75	Benzo(K)fluoranthene	0.00	0.00	0.00	0.00	0	7
76	Chrysene	0.00	0.00	0.00	0.00	0	7
77	Acenaphthylene	*	*	*	*	1	6
78	Anthracene	*	*	*	*	3	4
79	1,1,2-Benzoperylene	0.00	0.00	0.00	0.00	0	7
80	Fluorene	*	*	*	*	2	5
81	Phenanthrene	*	*	*	*	3	4
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0	7
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0	7
84	Pyrene	0.00	0.00	0.00	0.00	0	7
86	Toluene	0.00	0.00	0.00	0.00	0	3
87	Trichloroethylene	*	0.042	0.018	0.011	3	5
118	Cadmium	0.00	0.025	0.009	0.00	3	5
119	Chromium, Total	0.106	381.693	118.132	44.499	8	0
	Chromium, Hexavalent	0.002	177.978	51.370	32.557	7	1
120	Copper	0.001	0.077	0.023	0.014	6	2
121	Cyanide, Total	0.035	0.035	0.035	0.035	1	6
	Cyanide Am. to Chlor.	0.005	0.005	0.005	0.005	1	6
122	Lead	0.005	0.165	0.106	0.147	3	5
124	Nickel	0.005	9.485	4.720	4.695	4	4
128	Zinc	0.200	49.254	16.083	13.586	8	0
	Aluminum	0.095	0.761	0.415	0.432	5	3
	Fluorides	0.415	27.918	12.325	12.157	8	0
	Iron	1.556	6.807	4.607	4.901	8	0
	Manganese	0.062	0.465	0.198	0.172	8	0
	Phenols, Total	0.00	0.087	0.028	0.013	4	3
	Phosphorus	1.329	24.282	13.297	11.836	6	0
	Oil and Grease	0.566	6.798	2.573	1.480	6	1
	Total Dissolved Solids	133.836	1478.790	867.623	990.243	3	0
	Total Suspended Solids	6.769	84.191	43.945	47.790	8	0
	Minimum pH	3.3	11.4	5.8	4.3	8	0
	Maximum pH	5.1	11.5	7.7	7.5	8	0
	Temperature Deg C	20.0	53.7	36.5	41.2	8	0

* - Possibly detected but ≤ 0.010 mg/l

TABLE V-18
CLEANING RAW WASTEWATER POLLUTANTS (mg/l)
GALVANIZED SUBCATEGORY

	PARAMETER	MINIMUM	MAXIMUM	MEAN	MEDIAN	# PTS	# ZEROS
	Flow Liters/Day	14,940	327,020	99,820	87,740	11	0
11	1,1,1-Trichloroethane	*	*	*	*	4	6
13	1,1-Dichloroethane	0.00	0.00	0.00	0.00	0	1
29	1,1-Dichloroethylene	0.00	0.00	0.00	0.00	0	10
30	1,2-Trane-Dichloroethylene	0.00	0.00	0.00	0.00	0	10
34	2,4-Dimethylphenol	0.00	0.00	0.00	0.00	0	2
39	Fluoranthene	*	*	*	*	3	7
54	Isophorone	0.047	0.047	0.047	0.047	1	9
55	Naphthalene	*	0.038	0.019	0.019	2	8
65	Phenol	0.00	0.00	0.00	0.00	0	4
66	Bis(2-ethyhexl)phthalate	0.014	0.344	0.119	0.074	9	1
67	Butyl benzyl phthalate	0.128	0.128	0.128	0.128	1	9
68	Di-N-Butyl phthalate	*	0.173	0.043	0.025	7	3
69	Di-N-Octyl phthalate	*	*	*	*	1	9
70	Diethyl phthalate	*	0.419	0.138	0.087	8	2
71	Dimethyl phthalate	0.00	0.00	0.00	0.00	0	10
72	1,2-Benzanthracene	*	0.027	0.013	0.012	4	6
73	Benzo(A)pyrene	0.00	0.00	0.00	0.00	0	10
74	3,4-Benzofluoranthene	0.00	0.00	0.00	0.00	0	10
75	Benzo(k)fluoranthene	0.00	0.00	0.00	0.00	0	10
76	Chrysene	*	0.027	0.013	0.012	4	6
77	Acenaphthylene	0.00	0.00	0.00	0.00	0	10
78	Anthracene	*	0.250	0.090	0.020	3	7
79	1,1,2-Benzoperylene	0.00	0.00	0.00	0.00	0	10
80	Fluorene	*	0.085	0.033	0.024	4	6
81	Phenanthrene	*	0.047	0.022	0.020	3	7
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0	10
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0	10
84	Pyrene	*	*	*	*	3	7
86	Toluene	0.00	0.00	0.00	0.00	0	4
87	Trichloroethylene	*	*	*	*	2	8
118	Cadmium	0.006	0.120	0.045	0.040	8	2
119	Chromium, Total	0.059	0.610	0.314	0.270	9	1
	Chromium, Hexavalent	0.260	0.260	0.260	0.260	1	8
120	Copper	0.009	0.057	0.030	0.020	9	1
121	Cyanide, Total	0.012	0.043	0.022	0.017	4	6
	Cyanide Amn. to Chlor.	0.016	0.021	0.018	0.018	3	7
122	Lead	0.180	2.600	1.606	1.950	9	1
124	Nickel	0.150	0.150	0.150	0.150	1	9
128	Zinc	0.690	123.000	62.704	85.300	10	0
	Aluminum	0.410	4.860	2.441	1.300	9	1
	Fluorides	0.160	16.000	2.541	1.050	10	0
	Iron	0.190	17.500	4.766	1.025	10	0
	Manganese	0.012	0.730	0.193	0.160	9	1
	Phenols, Total	0.010	0.080	0.037	0.021	7	2
	Phosphorus	9.380	56.300	32.753	32.600	9	0
	Oil and Grease	10.200	969.000	263.750	107.500	10	0
	Total Dissolved Solids	204.000	204.000	204.000	204.000	1	0
	Total Suspended Solids	19.000	630.000	252.900	162.000	10	0
	Minimum pH	2.2	9.4	6.4	7.6	10	0
	Maximum pH	7.4	11.9	10.2	10.6	10	0
	Temperature Deg C	22.0	44.0	34.0	37.5	10	0

* - Possibly detected but $\leq$ 0.010 mg/l

TABLE V-19

CLEANING RAW WASTEWATER POLLUTANTS (mg/m^2)
GALVANIZED SUBCATEGORY

PARAMETER		MINIMUM	MAXIMUM	MEAN	MEDIAN	# PTS	# ZEROS
	Flow Liters/m^2	0.167	4.434	1.368	0.880	11	0
11	1,1,1-Trichloroethane	*	*	*	*	4	6
13	1,1-Dichloroethane	0.00	0.00	0.00	0.00	0	1
29	1,1-Dichloroethylene	0.00	0.00	0.00	0.00	0	10
30	1,2-Trans-Dichloroethylene	0.00	0.00	0.00	0.00	0	10
34	2,4-Dimethylphenol	0.00	0.00	0.00	0.00	0	2
39	Fluoranthene	*	*	*	*	3	7
54	Isophorone	0.038	0.038	0.038	0.038	1	9
55	Naphthalene	*	0.023	0.011	0.011	2	8
65	Phenol	0.00	0.00	0.00	0.00	0	4
66	Bis(2-ethyhexl)phthalate	0.011	0.638	0.145	0.034	9	1
67	Butyl benzyl phthalate	0.025	0.025	0.025	0.025	1	9
68	Di-N-Butyl phthalate	*	0.103	0.032	0.028	7	3
69	Di-N-Octyl phthalate	*	*	*	*	1	9
70	Diethyl phthalate	*	1.077	0.214	0.081	8	2
71	Dimethyl phthalate	0.00	0.00	0.00	0.00	0	10
72	1,2-Benzanthracene	*	0.018	*	*	4	6
73	Benzo(A)pyrene	0.00	0.00	0.00	0.00	0	10
74	3,4-Benzofluoranthene	0.00	0.00	0.00	0.00	0	10
75	Benzo(K)fluoranthene	0.00	0.00	0.00	0.00	0	10
76	Chrysene	*	0.018	0.009	0.008	4	6
77	Acenaphthylene	0.00	0.00	0.00	0.00	0	10
78	Anthracene	0.011	0.200	0.076	0.015	3	7
79	1,1,2-Benzoperylene	0.00	0.00	0.00	0.00	0	10
80	Fluorene	*	0.051	0.022	0.019	4	6
81	Phenanthrene	0.011	0.038	0.021	0.015	3	7
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0	10
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0	10
84	Pyrene	*	*	*	*	3	7
86	Toluene	0.00	0.00	0.00	0.00	0	4
87	Trichloroethylene	*	*	*	*	2	8
118	Cadmium	0.006	0.042	0.020	0.018	8	2
119	Chromium, Total	0.032	0.501	0.249	0.262	9	1
	Chromium, Hexavalent	0.043	0.043	0.043	0.043	1	8
120	Copper	0.002	0.084	0.032	0.028	9	1
121	Cyanide, Total	0.014	0.053	0.034	0.035	4	6
	Cyanide Amn. to Chlor.	0.014	0.026	0.018	0.016	3	7
122	Lead	0.067	1.935	1.136	1.309	9	1
124	Nickel	0.185	0.185	0.185	0.185	1	9
128	Zinc	0.115	123.593	54.113	69.325	10	0
	Aluminum	0.217	4.201	1.797	1.213	9	1
	Fluorides	0.256	2.665	1.072	0.938	10	0
	Iron	0.032	20.615	5.286	1.199	10	0
	Manganese	0.002	0.902	0.250	0.144	9	1
	Phenols, Total	0.003	0.068	0.032	0.029	7	2
	Phosphorus	4.997	67.387	32.395	33.192	9	0
	Oil and Grease	2.499	776.596	199.883	94.835	10	0
	Total Dissolved Solids	904.398	904.398	904.398	904.398	1	0
	Total Suspended Solids	3.165	499.298	233.834	195.161	10	0
	Minimum pH	2.2	9.4	6.4	7.6	10	0
	Maximum pH	7.4	11.9	10.2	10.6	10	0
	Temperature Deg C	22.0	44.0	34.0	37.5	10	0

* - Possibly detected but ≤ 0.010 mg/l

TABLE V-20
CONVERSION COATING RAW WASTEWATER POLLUTANTS (mg/l)
GALVANIZED SUBCATEGORY

	PARAMETER	MINIMUM	MAXIMUM	MEAN	MEDIAN	# PTS	# ZEROS
	Flow Liters/Day	1,820	75,490	36,340	48,690	11	0
11	1,1,1-Trichloroethane	0.016	0.142	0.052	0.025	4	6
13	1,1-Dichloroethane	0.00	0.00	0.00	0.00	0	1
29	1,1-Dichloroethylene	*	*	*	*	1	9
30	1,2-Trans-Dichloroethylene	*	0.015	0.008	0.008	2	8
34	2,4-Dimethylphenol	0.00	0.00	0.00	0.00	0	2
39	Fluoranthene	0.023	0.023	0.023	0.023	1	9
54	Isophorone	0.516	0.516	0.516	0.516	1	9
55	Naphthalene	*	0.015	*	*	5	5
65	Phenol	0.00	0.00	0.00	0.00	0	4
66	Bis(2-ethyhexl)phthalate	*	1.227	0.237	0.043	9	1
67	Butyl benzyl phthalate	*	*	*	*	3	7
68	Di-N-Butyl phthalate	*	0.020	*	*	3	7
69	Di-N-Octyl phthalate	0.00	0.00	0.00	0.00	0	10
70	Diethyl phthalate	0.015	0.299	0.086	0.051	9	1
71	Dimethyl phthalate	0.00	0.00	0.00	0.00	0	10
72	1,2-Benzanthracene	*	*	*	*	1	9
73	Benzo(A)pyrene	0.00	0.00	0.00	0.00	0	10
74	3,4-Benzofluoranthene	0.00	0.00	0.00	0.00	0	10
75	Benzo(K)fluoranthene	0.00	0.00	0.00	0.00	0	10
76	Chrysene	*	*	*	*	1	9
77	Acenaphthylene	*	*	*	*	1	9
78	Anthracene	*	0.288	0.096	*	3	7
79	1,1,2-Benzoperylene	0.00	0.00	0.00	0.00	0	10
80	Fluorene	*	*	*	*	1	9
81	Phenanthrene	*	0.288	0.096	*	3	7
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0	10
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0	10
84	Pyrene	0.011	0.011	0.011	0.011	1	9
86	Toluene	0.00	0.00	0.00	0.00	0	4
87	Trichloroethylene	0.029	0.114	0.072	0.072	2	8
118	Cadmium	0.008	0.110	0.042	0.010	5	5
119	Chromium, Total	3.380	785.000	291.914	119.850	10	0
	Chromium, Hexavalent	0.050	307.000	141.156	104.500	10	0
120	Copper	0.004	0.140	0.031	0.018	8	2
121	Cyanide, Total	0.120	0.470	0.290	0.200	5	5
	Cyanide Amn. to Chlor.	0.005	0.330	0.116	0.065	4	6
122	Lead	0.005	1.340	0.559	0.500	10	0
124	Nickel	0.033	30.860	7.584	4.430	6	4
128	Zinc	32.900	714.000	221.875	75.350	10	0
	Aluminum	1.300	10.600	3.606	2.310	9	1
	Fluorides	1.450	70.654	16.140	10.750	10	0
	Iron	0.840	20.800	6.583	5.050	10	0
	Manganese	0.035	1.303	0.253	0.118	10	0
	Phenols, Total	0.005	0.067	0.021	0.020	7	3
	Phosphorus	3.750	66.200	33.230	25.100	7	0
	Oil and Grease	1.264	106.000	18.806	10.500	10	0
	Total Dissolved Solids	2452.000	2452.000	2452.000	2452.000	1	0
	Total Suspended Solids	68.000	449.999	245.017	190.000	10	0
	Minimum pH	2.4	11.1	4.5	3.5	10	0
	Maximum pH	3.3	12.0	8.2	8.6	10	0
	Temperature Deg C	28.4	55.0	39.1	38.0	10	0

* - Possibly detected but $\leq$ 0.010 mg/l

TABLE V-21
CONVERSION COATING RAW WASTEWATER POLLUTANTS (mg/m^2)
GALVANIZED SUBCATEGORY

	PARAMETER	MINIMUM	MAXIMUM	MEAN	MEDIAN	# PTS	# ZEROS
	Flow Liters/m^2	0.025	1.269	0.528	0.575	11	0
11	1,1,1-Trichloroethane	*	0.060	0.020	*	4	6
13	1,1-Dichloroethane	0.00	0.00	0.000	0.00	0	1
29	1,1-Dichloroethylene	*	*	*	*	1	9
30	1,2-Trans-Dichloroethylene	*	0.013	*	*	2	8
34	2,4-Dimethylphenol	0.00	0.00	0.00	0.00	0	2
39	Fluoranthene	*	*	*	*	1	9
54	Isophorone	0.058	0.058	0.058	0.058	1	9
55	Naphthalene	*	*	*	*	5	5
65	Phenol	0.00	0.00	0.00	0.00	0	4
66	Bis(2-ethyhexl)phthalate	*	0.706	0.099	*	9	1
67	Butyl benzyl phthalate	*	*	*	*	3	7
68	Di-N-Butyl phthalate	*	0.013	0.004	*	3	7
69	Di-N-Octyl phthalate	0.00	0.00	0.00	0.00	0	10
70	Diethyl phthalate	*	0.178	0.035	0.017	9	1
71	Dimethyl phthalate	0.00	0.00	0.00	0.00	0	10
72	1,2-Benzanthracene	*	*	*	*	1	9
73	Benzo(A)pyrene	0.00	0.00	0.00	0.00	0	10
74	3,4-Benzofluoranthene	0.00	0.00	0.00	0.00	0	10
75	Benzo(K)fluoranthene	0.00	0.00	0.00	0.00	0	10
76	Chrysene	*	*	*	*	1	9
77	Acenaphthylene	*	*	*	*	1	9
78	Anthracene	*	0.032	0.011	*	3	7
79	1,1,2-Benzoperylene	0.00	0.00	0.00	0.00	0	10
80	Fluorene	*	*	*	*	1	9
81	Phenanthrene	*	0.032	0.011	*	3	7
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0	10
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0	10
84	Pyrene	*	*	*	*	1	9
86	Toluene	0.00	0.00	0.00	0.00	0	4
87	Trichloroethylene	0.017	0.048	0.033	0.033	2	8
118	Cadmium	0.001	0.047	0.018	0.001	5	5
119	Chromium, Total	0.083	87.529	58.335	59.657	10	0
	Chromium, Hexavalent	0.001	72.473	39.712	40.396	10	0
120	Copper	0.001	0.016	0.004	0.003	8	2
121	Cyanide, Total	0.085	0.305	0.177	0.115	5	5
	Cyanide Amn. to Chlor.	0.003	0.214	0.072	0.036	4	6
122	Lead	0.003	0.771	0.196	0.111	10	0
124	Nickel	0.002	18.340	3.294	0.387	6	4
128	Zinc	1.953	79.612	38.588	39.158	10	0
	Aluminum	0.099	4.495	1.241	1.001	9	1
	Fluorides	0.394	41.988	7.503	3.353	10	0
	Iron	0.483	3.489	1.383	1.143	10	0
	Manganese	0.005	0.775	0.098	0.024	10	0
	Phenols, Total	0.001	0.056	0.012	0.003	7	3
	Phosphorus	0.328	42.929	10.111	5.674	7	0
	Oil and Grease	0.217	64.290	9.172	1.934	10	0
	Total Dissolved Solids	60.392	60.392	60.392	60.392	1	0
	Total Suspended Solids	5.419	344.708	107.052	86.485	10	0
	Minimum pH	2.4	11.1	4.5	3.5	10	0
	Maximum pH	3.3	12.0	8.2	8.6	10	0
	Temperature Deg C	28.4	55.0	39.1	38.0	10	0

* - Possibly detected but $\leq$ 0.010 mg/l

TABLE V-22
CLEANING RAW WASTEWATER POLLUTANTS (mg/l)
ALUMINUM SUBCATEGORY

	PARAMETER	MINIMUM	MAXIMUM	MEAN	MEDIAN	# PTS	# ZEROS
	Flow Liters/Day	14,640	163,510	84,430	84,670	12	0
39	Fluroanthene	0.00	0.00	0.00	0.00	0	12
54	Isophorone	0.00	0.00	0.00	0.00	0	12
55	Naphthalene	*	*	*	*	3	9
65	Phenol	0.00	0.00	0.00	0.00	0	2
66	Bis(2-ethylhexyl)phthalate	*	0.450	0.131	0.010	10	2
67	Butyl benzyl phthalate	0.00	0.00	0.00	0.00	0	12
68	Di-N-Butyl phthalate	*	0.012	0.006	0.006	2	10
69	Di-N-Octyl phthalate	0.00	0.00	0.00	0.00	0	12
70	Diethyl phthalate	0.020	0.450	0.171	0.080	7	5
71	Dimethyl phthalate	*	*	*	*	2	10
72	1,2-Benzanthracene	0.00	0.00	0.00	0.00	0	12
73	Benzo(A)pyrene	*	*	*	*	3	9
74	3,4-Benzofluoranthene	0.00	0.00	0.00	0.00	0	12
75	Benzo(K)fluoranthene	0.00	0.00	0.00	0.00	0	12
76	Chrysene	0.00	0.00	0.00	0.00	0	12
77	Acenaphthylene	0.00	0.00	0.00	0.00	0	12
78	Anthracene	*	*	*	*	2	10
79	1,1,2-Benzoperylene	0.00	0.00	0.00	0.00	0	12
80	Fluorene	*	*	*	*	1	11
81	Phenanthrene	*	*	*	*	2	10
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0	12
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0	12
84	Pyrene	0.00	0.00	0.00	0.00	0	12
86	Toluene	0.00	0.00	0.00	0.00	0	2
118	Cadmium	0.003	0.021	0.009	0.003	3	9
119	Chromium, Total	0.028	6.020	1.263	0.180	9	3
	Chromium, Hexavalent	6.580	6.580	6.580	6.580	1	10
120	Copper	0.009	0.210	0.084	0.075	9	3
121	Cyanide, Total	0.005	0.260	0.040	0.010	9	3
	Cyanide Amn. to Chlor.	0.005	0.240	0.038	0.006	8	4
122	Lead	0.060	0.220	0.144	0.170	5	7
124	Nickel	0.00	0.00	0.00	0.00	0	12
128	Zinc	0.013	14.000	1.589	0.210	10	2
	Aluminum	8.550	940.000	397.720	251.500	12	0
	Fluorides	0.430	9.500	2.020	0.800	9	3
	Iron	0.077	0.690	0.345	0.275	12	0
	Manganese	0.021	14.700	4.993	1.330	9	3
	Phenols, Total	0.010	0.160	0.047	0.020	11	1
	Phosphorus	0.690	101.000	62.947	90.400	6	3
	Oil & Grease	1.000	2800.000	530.877	75.000	9	3
	Total Suspended Solids	6.000	970.000	183.767	49.000	12	0
	Minimum pH	7.1	11.0	9.4	10.1	12	0
	Maximum pH	8.4	11.9	10.6	11.2	12	0
	Temperature Deg C	26.5	60.3	36.8	33.3	12	0

* - Possibly detected by ≤ 0.010 mg/l

TABLE V-23
CLEANING RAW WASTEWATER POLLUTANTS (mg/m^2)
ALUMINUM SUBCATEGORY

	PARAMETER	MINIMUM	MAXIMUM	MEAN	MEDIAN	# PTS	# ZEROS
	Flow Liters/m^2	0.164	1.965	0.964	0.973	12	0
39	Fluroanthene	0.00	0.00	0.00	0.00	0	12
54	Isophorone	0.00	0.00	0.00	0.00	0	12
55	Naphthalene	*	*	*	*	3	9
65	Phenol	0.00	0.00	0.00	0.00	0	2
66	Bis(2-ethylhexyl)phthalate	*	0.424	0.083	0.020	10	2
67	Butyl benzyl phthalate	0.00	0.00	0.00	0.00	0	12
68	Di-N-Butyl phthalate	*	*	*	*	2	10
69	Di-N-Octyl phthalate	0.00	0.00	0.00	0.00	0	12
70	Diethyl phthalate	0.038	0.884	0.222	0.106	7	5
71	Dimethyl phthalate	*	*	*	*	2	10
72	1,2-Benzanthracene	0.00	0.00	0.00	0.00	0	12
73	Benzo(A)pyrene	*	*	*	*	3	9
74	3,4-Benzofluoranthene	0.00	0.00	0.00	0.00	0	12
75	Benzo(K)fluoranthene	0.00	0.00	0.00	0.00	0	12
76	Chrysene	0.00	0.00	0.00	0.00	0	12
77	Acenaphthylene	0.00	0.00	0.00	0.00	0	12
78	Anthracene	*	*	*	*	2	10
79	1,1,2-Benzoperylene	0.00	0.00	0.00	0.00	0	12
80	Fluorene	*	*	*	*	1	11
81	Phenanthrene	*	*	*	*	2	10
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0	12
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0	12
84	Pyrene	0.00	0.00	0.00	0.00	0	12
86	Toluene	0.00	0.00	0.00	0.00	0	12
118	Cadmium	0.002	0.010	0.005	0.003	3	9
119	Chromium, Total	0.028	5.669	0.782	0.070	9	3
	Chromium, Hexavalent	6.196	6.196	6.196	6.196	1	10
120	Copper	0.009	0.131	0.042	0.022	9	3
121	Cyanide, Total	0.001	0.268	0.041	0.010	9	3
	Cyanide Amn. to Chlor.	0.001	0.248	0.039	0.010	8	4
122	Lead	0.029	0.061	0.043	0.041	5	7
124	Nickel	0.00	0.00	0.00	0.00	0	12
128	Zinc	0.013	13.184	1.502	0.163	10	2
	Aluminum	16.261	458.810	187.162	137.389	12	0
	Fluorides	0.211	2.036	1.065	1.231	9	3
	Iron	0.131	0.381	0.222	0.200	12	0
	Manganese	0.021	3.901	1.372	0.652	9	3
	Phenols, Total	0.003	0.087	0.029	0.019	11	1
	Phosphorus	0.742	95.110	36.879	33.839	6	3
	Oil & Grease	0.478	1,747.847	352.190	20.897	9	3
	Total Suspended Solids	9.293	605.504	116.946	40.638	12	0
	Minimum pH	7.1	11.0	9.4	10.1	12	0
	Maximum pH	8.4	11.9	10.6	11.2	12	0
	Temperature Deg C	26.5	60.3	36.8	33.3	12	0

* - Possibly detected by ≤ 0.010 mg/l

TABLE V-24
CONVERSION COATING RAW WASTEWATER POLLUTANTS (mg/l)
ALUMINUM SUBCATEGORY

	PARAMETER	MINIMUM	MAXIMUM	MEAN	MEDIAN	# PTS	# ZEROS
	Flow Liters/Day	11,620	61,320	42,160	47,560	12	0
39	Fluroanthene	0.00	0.00	0.00	0.00	0	12
54	Isophorone	0.00	0.00	0.00	0.00	0	12
55	Naphthalene	*	*	*	*	3	9
65	Phenol	0.00	0.00	0.00	0.00	0	2
66	Bis(2-ethylhexyl)phthalate	*	0.300	0.049	0.020	9	3
67	Butyl benzyl phthalate	0.00	0.00	0.00	0.00	0	12
68	Di-N-Butyl phthalate	*	*	*	*	2	10
69	Di-N-Octyl phthalate	*	*	*	*	1	11
70	Diethyl phthalate	*	0.200	0.076	0.050	9	3
71	Dimethyl phthalate	0.110	0.110	0.110	0.110	1	11
72	1,2-Benzanthracene	0.00	0.00	0.00	0.00	0	12
73	Benzo(A)pyrene	*	*	*	*	2	10
74	3,4-Benzofluoranthene	0.00	0.00	0.00	0.00	0	12
75	Benzo(K)fluoranthene	0.00	0.00	0.00	0.00	0	12
76	Chrysene	0.00	0.00	0.00	0.00	0	12
77	Acenaphthylene	0.00	0.00	0.00	0.00	0	12
78	Anthracene	*	*	*	*	4	8
79	1,1,2-Benzoperylene	0.00	0.00	0.00	0.00	0	12
80	Fluorene	0.00	0.00	0.00	0.00	0	12
81	Phenanthrene	*	*	*	*	4	8
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0	12
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0	12
84	Pyrene	0.00	0.00	0.00	0.00	0	12
86	Toluene	0.00	0.00	0.00	0.00	0	2
118	Cadmium	0.003	0.019	0.010	0.008	3	9
119	Chromium, Total	15.000	965.000	269.500	117.500	12	0
	Chromium, Hexavalent	10.800	333.000	119.050	92.500	12	0
120	Copper	0.011	0.980	0.187	0.052	10	2
121	Cyanide, Total	0.017	7.500	3.229	2.570	9	3
	Cyanide Amn. to Chlor.	0.009	7.060	2.090	1.373	6	3
122	Lead	0.170	0.400	0.285	0.285	2	10
124	Nickel	0.018	0.260	0.124	0.108	4	8
128	Zinc	0.016	42.600	8.756	0.540	12	0
	Aluminum	10.900	410.000	163.591	107.500	12	0
	Fluorides	17.500	510.000	205.625	31.000	12	0
	Iron	0.830	86.900	20.802	7.815	12	0
	Manganese	0.049	11.700	1.369	0.340	12	0
	Phenols, Total	0.004	0.140	0.030	0.011	8	4
	Phosphorus	13.100	15.900	14.500	14.500	2	0
	Oil & Grease	0.200	60.000	9.433	2.000	9	3
	Total Suspended Solids	4.200	1,199.999	162.733	55.000	12	0
	Minimum pH	1.6	5.4	3.0	2.5	12	0
	Maximum pH	3.7	6.7	5.2	5.1	12	0
	Temperature Deg C	26.5	45.1	33.4	30.3	12	0

* - Possibly detected by $\leq$ 0.010 mg/l

TABLE V-25
CONVERSION COATING RAW WASTEWATER POLLUTANTS (mg/m^2)
ALUMINUM SUBCATEGORY

	PARAMETER	MINIMUM	MAXIMUM	MEAN	MEDIAN	# PTS	# ZEROS
	Flow Liters/m^2	0.137	1.751	0.546	0.467	12	0
39	Fluroanthene	0.00	0.00	0.00	0.00	0	12
54	Isophorone	0.00	0.00	0.00	0.00	0	12
55	Naphthalene	*	*	*	*	3	9
65	Phenol	0.00	0.00	0.00	0.00	0	2
66	Bis(2-ethylhexyl)phthalate	*	0.064	0.013	*	9	3
67	Butyl benzyl phthalate	0.00	0.00	0.00	0.00	0	12
68	Di-N-Butyl phthalate	*	*	*	*	2	10
69	Di-N-Octyl phthalate	*	*	*	*	1	11
70	Diethyl phthalate	*	0.085	0.030	0.025	9	3
71	Dimethyl phthalate	0.047	0.047	0.047	0.047	1	11
72	1,2-Benzanthracene	0.00	0.00	0.00	0.00	0	12
73	Benzo(A)pyrene	*	*	*	*	2	10
74	3,4-Benzofluoranthene	0.00	0.00	0.00	0.00	0	12
75	Benzo(K)fluoranthene	0.00	0.00	0.00	0.00	0	12
76	Chrysene	0.00	0.00	0.00	0.00	0	12
77	Acenaphthylene	0.00	0.00	0.00	0.00	0	12
78	Anthracene	*	*	*	*	4	8
79	1,1,2-Benzoperylene	0.00	0.00	0.00	0.00	0	12
80	Fluorene	0.00	0.00	0.00	0.00	0	12
81	Phenanthrene	*	*	*	*	4	8
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0	12
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0	12
84	Pyrene	0.00	0.00	0.00	0.00	0	12
86	Toluene	0.00	0.00	0.00	0.00	0	12
118	Cadmium	0.004	0.012	0.007	0.005	3	9
119	Chromium, Total	9.656	665.404	167.554	44.630	12	0
	Chromium, Hexavalent	8.487	320.445	75.618	29.635	12	0
120	Copper	0.006	0.260	0.082	0.012	10	2
121	Cyanide, Total	0.004	3.152	1.517	1.665	9	3
	Cyanide Amn. to Chlor.	0.002	3.007	0.879	0.563	6	3
122	Lead	0.094	0.260	0.177	0.177	2	10
124	Nickel	0.006	0.169	0.072	0.057	4	8
128	Zinc	0.007	74.595	9.214	0.274	12	0
	Aluminum	5.534	288.925	79.781	35.281	12	0
	Fluorides	8.894	324.515	78.333	36.769	12	0
	Iron	0.149	36.522	9.159	2.976	12	0
	Manganese	0.020	2.589	0.472	0.142	12	0
	Phenols, Total	0.001	0.091	0.016	0.004	8	4
	Phosphorus	5.506	6.771	6.138	6.138	2	0
	Oil & Grease	0.084	105.064	13.232	1.016	9	3
	Total Suspended Solids	1.254	2101.275	200.044	26.414	12	0
	Minimum pH	1.6	5.4	3.0	2.5	12	0
	Maximum pH	3.7	6.7	5.2	5.1	12	0
	Temperature Deg C	26.5	45.1	33.4	30.3	12	0

* - Possibly detected by $\leq$ 0.010 mg/l

TABLE V-26
QUENCHING RAW WASTEWATER POLLUTANTS (mg/l)
ALL SUBCATEGORIES

	PARAMETER	MINIMUM	MAXIMUM	MEAN	MEDIAN	# PTS	# ZEROS
	Flow Liters/Day	39,240	693,200	285,120	249,810	22	0
11	1,1,1-Trichloroethane	*	3.085	0.897	0.251	4	5
13	1,1-Dichloroethane	0.00	0.00	0.00	0.00	0	3
29	1,1-Dichloroethylene	0.036	0.036	0.036	0.036	1	5
30	1,2-Trans-Dichloroethylene	0.043	0.043	0.043	0.043	1	5
34	2,4-Dimethylphenol	0.00	0.00	0.00	0.00	0	3
39	Fluoranthene	*	*	*	*	1	17
54	Isophorone	0.00	0.00	0.00	0.00	0	18
55	Naphthalene	*	*	*	*	3	15
65	Phenol	0.00	0.00	0.00	0.00	0	7
66	Bis(2-ethyhexl)phthalate	*	0.880	0.092	0.017	14	4
67	Butyl benzyl phthalate	*	0.015	0.008	0.008	2	16
68	Di-N-Butyl phthalate	*	0.020	0.003	*	6	12
69	Di-N-Octyl phthalate	*	*	*	*	1	17
70	Diethyl phthalate	*	0.330	0.07	0.050	15	3
71	Dimethyl phthalate	*	*	*	*	2	16
72	1,2-Benzanthracene	0.00	0.00	0.00	0.00	0	18
73	Benzo(A)pyrene	*	*	*	*	1	17
74	3,4-Benzofluoranthene	*	*	*	*	1	17
75	Benzo(K)fluoranthene	*	*	*	*	1	17
76	Chrysene	0.00	0.00	0.00	0.00	0	18
77	Acenaphthylene	0.00	0.00	0.00	0.00	0	18
78	Anthracene	*	*	*	*	2	16
79	1,1,2-Benzoperylene	*	*	*	*	1	17
80	Fluorene	0.00	0.00	0.00	0.00	0	18
81	Phenanthrene	*	*	*	*	2	16
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0	18
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0	18
84	Pyrene	0.00	0.00	0.00	0.00	0	18
86	Toluene	0.00	0.00	0.00	0.00	0	7
87	Trichloroethylene	*	3.070	0.729	*	5	4
118	Cadmium	0.008	0.270	0.097	0.014	3	17
119	Chromium, Total	0.004	0.440	0.057	0.013	15	5
	Chromium, Hexavalent	0.00	0.00	0.00	0.00	0	20
120	Copper	0.004	0.017	0.008	0.006	7	13
121	Cyanide, Total	0.005	0.200	0.039	0.021	17	3
	Cyanide Amn. to Chlor.	0.005	0.080	0.026	0.019	11	9
122	Lead	0.032	0.064	0.048	0.048	2	18
124	Nickel	0.190	0.190	0.190	0.190	1	19
128	Zinc	0.014	4.990	0.606	0.150	20	0
	Aluminum	0.460	1.350	0.960	1.025	8	12
	Fluorides	0.150	11.000	1.640	0.850	20	0
	Iron	0.018	1.580	0.370	0.136	20	0
	Manganese	0.002	0.780	0.179	0.021	15	5
	Phenols, Total	0.003	0.040	0.016	0.015	15	5
	Phosphorus	0.250	15.400	3.234	0.780	11	7
	Oil and Grease	1.000	26.000	7.125	5.000	15	5
	Total Dissolved Solids	99.000	1,080.000	437.000	132.000	3	0
	Total Suspended Solids	0.010	24.000	6.895	5.000	18	2
	Minimum pH	4.9	8.0	6.8	6.8	20	0
	Maximum pH	7.2	9.0	7.9	7.7	20	0
	Temperature Deg C	23.00	42.3	31.9	30.2	20	0

* - Possibly detected but ≤ 0.010 mg/l

TABLE V-27
QUENCHING RAW WASTEWATER POLLUTANTS (mg/m^2)
ALL SUBCATEGORIES

	PARAMETER	MINIMUM	MAXIMUM	MEAN	MEDIAN	# PTS	# ZEROS
	Flow Liters/m^2	0.436	8.03	3.632	3.296	22	0
11	1,1,1-Trichloroethane	*	0.897	0.269	0.090	4	5
13	1,1-Dichloroethane	0.00	0.00	0.00	0.00	0	3
29	1,1-Dichloroethylene	*	*	*	*	1	5
30	1,2-Trans-Dichloroethylene	0.013	0.013	0.013	0.013	1	5
34	2,4-Dimethylphenol	0.00	0.00	0.00	0.00	0	3
39	Fluoranthene	*	*	*	*	1	17
54	Isophorone	0.00	0.00	0.00	0.00	0	18
55	Naphthalene	*	*	*	*	3	15
65	Phenol	0.00	0.00	0.00	0.00	0	7
66	Bis(2-ethyhexl)phthalate	*	0.256	0.076	0.034	14	4
67	Butyl benzyl phthalate	*	0.026	0.013	0.013	2	16
68	Di-N-Butyl phthalate	*	0.033	*	*	6	12
69	Di-N-Octyl phthalate	0.014	0.014	0.014	0.014	1	17
70	Diethyl phthalate	*	0.780	0.172	0.064	15	3
71	Dimethyl phthalate	*	*	*	*	2	16
72	1,2-Benzanthracene	0.00	0.00	0.00	0.00	0	18
73	Benzo(A)pyrene	*	*	*	*	1	17
74	3,4-Benzofluoranthene	*	*	*	*	1	17
75	Benzo(K)fluoranthene	*	*	*	*	1	17
76	Chrysene	0.00	0.00	0.00	0.00	0	18
77	Acenaphthylene	0.00	0.00	0.00	0.00	0	18
78	Anthracene	*	*	*	*	2	16
79	1,1,2-Benzoperylene	*	*	*	*	1	17
80	Fluorene	0.00	0.00	0.00	0.00	0	18
81	Phenanthrene	*	*	*	*	2	16
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0	18
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0	18
84	Pyrene	0.00	0.00	0.00	0.00	0	18
86	Toluene	0.00	0.00	0.00	0.00	0	7
87	Trichloroethylene	0.00	0.893	0.215	0.017	5	4
118	Cadmium	0.019	0.684	0.244	0.029	3	17
119	Chromium, Total	0.010	0.138	0.051	0.031	15	5
	Chromium, Hexavalent	0.00	0.00	0.00	0.00	0	20
120	Copper	0.003	0.037	0.015	0.012	7	13
121	Cyanide, Total	0.007	0.249	0.073	0.045	17	3
	Cyanide Amn. to Chlor.	0.009	0.129	0.057	0.032	11	9
122	Lead	0.104	0.328	0.216	0.216	2	18
124	Nickel	0.615	0.615	0.615	0.615	1	19
128	Zinc	0.019	25.599	2.243	0.153	20	0
	Aluminum	0.337	3.226	1.449	1.300	8	12
	Fluorides	0 215	3.398	1.564	1.446	20	0
	Iron	0.017	4.139	0.734	0.281	20	0
	Manganese	0.003	4.002	0.679	0.026	15	5
	Phenols, Total	0.001	0.094	0.033	0.027	15	5
	Phosphorus	0.207	4.478	2.408	2.272	11	7
	Oil and Grease	0.825	35.464	10.514	7.560	15	5
	Total Dissolved Solids	170.683	1452.142	666.540	376.796	3	0
	Total Suspended Solids	0.017	57.090	14.665	9.539	18	2
	Minimum pH	4.9	8.0	6.8	6.8	20	0
	Maximum pH	7.2	9.0	7.9	7.7	20	0
	Temperature Deg C	23.0	42.3	31.9	30.2	20	0

* - Possibly detected but ≤ 0.010 mg/l

TABLE V-28

SUMMARY OF CLEANING RAW WASTEWATER POLLUTANTS
(MEDIAN VALUE)

Parameter		Steel		Galvanized		Aluminum	
		mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2
	Flow Liters/day	130,810		87,590		84,670	
	Flow Liters/m^2		1.498		0.880		0.973
39	Fluoranthene	0.068	0.109	*	*	0.00	0.00
54	Isophorone	0.018	0.132	0.047	0.038	0.00	0.00
55	Naphthalene	*	0.690	0.019	0.011	*	*
66	Bis (2-ethylhexyl) phthalate	0.020	0.033	0.074	0.034	*	0.020
67	Butyl benzyl phthalate	0.358	0.574	0.128	0.025	0.00	0.00
68	Di-N-Butyl phthalate	*	*	0.025	0.028	*	*
70	Diethyl phthalate	0.030	0.042	0.087	0.081	0.080	0.106
71	Dimethyl phthalate	0.00	0.00	0.00	0.00	*	*
72	1,2-Benzanthracene	0.015	0.022	0.012	0.008	0.00	0.00
76	Chrysene	0.015	0.022	0.012	0.008	0.00	0.00
78	Anthracene	*	*	0.020	0.015	*	*
80	Fluorene	*	*	0.024	0.019	*	*
81	Phenanthrene	*	*	0.020	0.015	*	*
118	Cadmium	0.005	0.005	0.040	0.018	0.003	0.003
119	Chromium, Total	0.183	0.330	0.270	0.262	0.180	0.070
	Chromium, Hexavalent			0.260	0.043	6.580	6.196
120	Copper	0.059	0.090	0.020	0.028	0.075	0.022
121	Cyanide, Total	0.024	0.066	0.017	0.035	0.010	0.010
	Cyanide Amn. to Chlor.	0.028	0.044	0.018	0.016	0.010	0.010
122	Lead	0.458	0.241	1.950	1.309	0.170	0.041
124	Nickel	0.039	0.062	0.150	0.185		
128	Zinc	3.200	3.185	85.300	69.330	0.210	0.163
	Aluminum	0.340	0.513	1.300	1.213	251.500	137.400
	Fluorides	0.980	1.388	1.050	0.938	0.800	1.231
	Iron	5.200	38.169	1.030	1.199	0.275	0.200
	Manganese	0.630	1.245	0.160	0.144	1.330	0.652
	Phenols, Total	0.020	0.147	0.021	0.029	0.020	0.019
	Phosphorus	42.300	50.860	32.600	33.192	90.400	33.839
	Oil & Grease	261.000	313.000	107.500	94.835	75.000	20.897
	Total Dissolved Solids	9,341.000	17,432.000	204.000	904.398		
	Total Suspended Solids	256.000	231.000	162.000	195.200	49.000	40.638
	Minimum pH	8.5	8.5	7.6	7.6	10.1	10.1
	Maximum pH	10.6	10.6	10.6	10.6	11.1	11.1
	Temperature °C	37.7	37.7	37.5	37.5	33.3	33.3

* - possibly detected but ≤ 0.010 mg/l

TABLE V-29

SUMMARY OF CONVERSION COATING RAW WASTEWATER POLLUTANTS
(MEDIAN VALUE)

	Parameter	Steel		Galvanized		Aluminum	
		mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2
	Flow Liters/day	38,150		48,690		47,560	
	Flow Liters/m^2		0.377		0.575		0.467
11	1,1,1-Trichloroethane	*	*	0.025	0.009	0.0	0.0
13	1,1-Dichloroethane	0.077	0.034				
34	2,4-Dimethylphenol						
39	Fluoranthene	*	*	0.023	*	0.00	0.00
54	Isophorone	0.00	0.00	0.516	0.058	0.00	0.00
66	Bis (2-ethylhexyl) phthalate	0.014	*	0.043	*	0.020	*
69	Di-N-Octyl-phthalate	0.760	0.332			*	*
70	Diethyl phthalate	0.135	0.069	0.051	0.017	0.050	0.025
71	Dimethyl phthalate	0.00	0.00	0.00	0.00	0.110	0.047
84	Pyrene	0.00	0.00	0.011	*	0.00	0.00
87	Trichloroethylene	0.014	0.011	0.072	0.033		
118	Cadmium	0.006		0.010	0.001	0.008	0.005
119	Chromium, Total	71.08	44.499	119.850	59.657	117.50	44.630
	Chromium, Hexavalent	42.890	32.557	104.500	40.396	95.50	29.635
120	Copper	0.032	0.014	0.018	0.003	0.052	0.012
121	Cyanide, Total	0.092	0.035	0.200	0.115	2.570	1.665
	Cyanide Amn. to Chlor.	0.012	0.005	0.065	0.036	1.373	0.563
122	Lead	0.480	0.147	0.500	0.111	0.285	0.177
124	Nickel	6.762	4.695	4.430	0.387	0.108	0.057
128	Zinc	51.264	13.586	75.350	39.158	0.540	0.274
	Aluminum	1.190	0.432	2.310	1.001	107.50	35.281
	Fluorides	27.428	12.157	10.750	3.353	31.00	36.769
	Iron	9.233	4.901	5.050	1.143	7.815	2.976
	Manganese	0.485	0.172	0.118	0.024	0.340	0.142
	Phenols, Total	0.019	0.013	0.020	0.003	0.011	0.004
	Phosphorus	43.400	11.836	25.100	5.674	14.500	6.118
	Oil & Grease	6.600	1.480	10.500	1.934	2.000	1.016
	Total Dissolved Solids	3,390.000	990.243	2452.000	60.392		
	Total Suspended Solids	133.500	47.790	190.000	86.485	55.000	26.414
	Minimum pH	4.3	4.3	3.5	3.5	2.5	2.5
	Maximum pH	7.5	7.5	8.6	8.6	5.1	5.1
	Temperature °C	41.2	41.2	38.0	38.0	30.3	30.3

* - possibly detected but $\leq$ 0.010 mg/l

TABLE V-30

SUMMARY OF QUENCHING WASTEWATER POLLUTANTS
(Median Value)

	PARAMETER	mg/l	mg/m^2
	Flow liters/day	249,810	
	Flow liters/m^2		3.296
11	1,1,1-Trichloroethane	0.251	0.090
29	1-1-Dichloroethylene	0.036	0.010
30	1-2-T Dichloroethylene	0.043	0.013
66	Bis(2-ethylhexyl)phthalate	0.017	0.034
70	Diethyl phthalate	0.050	0.064
118	Cadmium	0.014	0.029
119	Chromium, Total	0.013	0.031
120	Copper	0.006	0.012
121	Cyanide, Total	0.021	0.045
	Cyanide Amn. to Chlor.	0.019	0.032
122	Lead	0.048	0.216
124	Nickel	0.190	0.615
128	Zinc	0.150	0.153
	Aluminum	1.025	1.300
	Fluorides	0.850	1.446
	Iron	0.136	0.281
	Manganese	0.021	0.026
	Phenols, Total	0.015	0.027
	Phosphorus	0.780	2.272
	Oil & Grease	5.000	7.560
	Total Dissolved Solids	132.000	376.800
	Total Suspended Solids	5.000	9.539
	Minimum pH	6.8	6.8
	Maximum pH	7.7	7.7
	Temperature Deg C	30.2	30.2

TABLE V-31

SUMMARY OF TOTAL RAW WASTEWATER POLLUTANTS
(MEDIAN VALUE)

		Steel		Galvanized		Aluminum	
	Parameter	mg/l	mg/m2	mg/l	mg/m2	mg/l	mg/m2
	Flow Liters/day	497621.0		134004.0		209295.0	
	Flow Liters/m2		5.17		4.75		4.736
1	Acenaphthene	0.00	0.00			0.00	0.00
11	1,1,1-Trichloroethane	*	*	0.011	0.064	-	-
13	1,1,-Dichloroethane	0.018	0.034	*	0.00		
29	1,1-Dichloroethylene	0.00	0.00	0.015	0.016		
30	1,2-Trans-Dichloroethylene	-	-	0.009	0.019	-	-
34	2,4-Dimethylphenol	0.021	0.032	0.00	0.00		
39	Fluoranthene	0.040	0.036	*	*	*	*
54	Isophorone	0.600	0.909	*	*	0.00	0.00
55	Naphthalene	*	*	*	*	*	*
65	Phenol	0.016	0.024	0.00	*	0.00	0.00
66	Bis (2-ethylhexyl) phthalate	0.035	0.050	0.030	0.177	0.014	0.047
67	Butyl benzyl phthalate	0.152	0.300	*	*	*	*
68	Di-n-butylphthalate	*	*	*	*	*	*
69	Di-N-Octyl phthalate	0.027	0.031	*	*	*	*
70	Diethyl phthalate	0.056	0.158	0.048	0.174	0.056	0.188
71	Dimethyl phthalate	0.00	0.00	*	*	*	*
72	1,2-Benzanthracene	0.056	0.044	*	*	0.00	0.00
73	Benzo (a) pyrene	*	*	*	*	*	*
74	3,4-Benzofluoranthrene	0.035	0.023	*	*	*	*
75	11,12-Benzo(K)fluoranthene	0.035	0.023	*	*	*	*
76	Chrysene	0.023	0.040	*	*	0.00	0.00
77	Acenaphthalene	*	*	*	*	0.00	0.00
78	Anthracene	0.064	0.097	*	*	*	*
79	1,12-Benzoperylene	0.00	0.00	0.00	0.00	*	*
80	Fluorene	0.028	0.100	*	*	*	*
81	Phenanthrene	0.064	0.097	*	*	*	*
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0.00	0.00
83	Indeno (1,2,3-cd)pyrene	0.00	0.00	0.00	0.00	0.00	0.00
84	Pyrene	0.012	0.024	*	*	0.00	0.00
86	Toluene	*	*	0.00	0.00	*	*
87	Trichloroethylene	*	*	*	*	-	-
118	Cadmium	0.001	0.002	0.045	0.039	0.005	0.023
119	Chromium, Total	6.865	31.132	57.600	60.879	43.50	48.378
	Chromium, Hexavalent	4.360	32.557	9.350	29.711	13.146	36.919
120	Copper	0.051	0.100	0.009	0.033	0.043	0.031
121	Cyanide, Total	0.012	0.106	0.082	0.302	0.568	2.303
	Cyanide Amn. to Chlor.	0.016	0.112	0.032	0.154	0.172	0.564
122	Lead	0.142	0.310	0.422	0.919	0.118	0.135
124	Nickel	0.392	0.324	0.395	0.330	0.003	0.057
128	Zinc	7.588	28.046	25.489	81.829	0.028	0.176
	Aluminum	0.607	0.886	1.741	2.948	112.212	160.460
	Fluorides	3.576	8.339	2.115	9.101	21.000	29.933
	Iron	10.145	23.319	2.829	4.776	3.448	3.395
	Manganese	0.533	1.387	0.117	0.190	0.370	0.465
	Phenols, Total	0.020	0.117	0.008	0.053	0.026	0.065
	Phosphorus	42.874	66.389	14.758	34.169	7.000	8.591
	Oil & Grease	341.650	655.170	52.965	150.061	57.561	33.118
	Total Dissolved Solids	1665.750	10240.760	428.693	1306.156	1130.000	1373.636
	Total Suspended Solids	152.79	669.081	114.053	404.310	84.884	120.578
	Minimum pH	6.2	6.2	3.5	3.5	2.5	2.5
	Maximum pH	11.5	11.5	11.1	11.1	11.1	11.1
	Temperature °C	32.2	32.2	34.3	34.3	31.0	31.1

* possibly detected but ≤ 0.010 mg/l

- indicates not a verification parameter in respective category

0.00 indicates the parameter was not detected in all samples for which it was analyzed

TABLE V-32

SUMMARY OF VISITED PLANTS WASTEWATER TREATMENT

Plant ID and Discharge Type	Raw Wastewater's Destination								
	CLEANING					CONVERSION COATING			
	Discharged w/o Treatment	pH Adjust and Discharge w/o Treatment	To Wastewater Treatment	pH Adjust and to Wastewater Treatment	Discharge Rinses w/o Treatment	Chrome Reduction then to Wastewater Treatment	To Wastewater Treatment	Chrome & Cyanide Treatment Wastewater Treatment	Chromium Regenerating
01057 D	X						X		
11055 I			X				X		
11058 I Line #1			X				X		
11058 I Line #2			X				X		
12652 I Line #1	X					of sealing rinse only then to settling	of rinses only		
12052 I Line #2		X				of sealing rinse only then to settling of sludge	of rinses only		
15436 D			Test spray to Chrome red X			X			
33056 O			X			X			
36056 I Zincromet			X		X		X		
38053 I			Acid pickle rinses are recycled				X		X
40064 O	X					X			
46050 D			X			chromic acid rinse	Rinse after Conversion coating		

TABLE V-32 (CONTINUED)
SUMMARY OF VISITED PLANTS WASTEWATER TREATMENT

Plant ID and Discharge Type	RAW WASTEWATER'S DESTINATION				WASTEWATER TREATMENT OPERATIONS						
		QUENCHING									
	Discharge without Treatment	To Wastewater	100% Recycle through cooling Tower	Reuse in Clean or Conv. Coat.	Chromium Reduction	Oil Removal	Cyanide Treatment	pH adjust	Clarification	Sludge dewatering	Polishing Filter
01054 D			X						Tube settler	Vacuum Filter	
01057 I	X				X		$FeSO_4$ precipation	X	Lagoons no actual discharge stream		X
11055 I			X		X	Skimming		X	Settling Clarifier	Filter press	
11058 I Line #1			X		X	Skimming		X	Settling Clarifier	Filter press	
11058 I Line #2			X								
12052 I Line #1	X							X	Clarifier	Sludge Settling	
12052 I Line #2	X										
15436 D			X					X Lime	Clarifier		
13029 I	X				X (all wastes)			X NaOH CaOH	Tube settling Tanks	Filter Press (filtrate back to chrome red)	
33056 O		Only prime Quench		Only rinse Quench		Skimmer not used during visit		H SO & flocculant	Settling Tank	Lagoon	Pressure Filtration
36056 I			X		X	Oil skimmer		Lime	Clarifier	Vacuum Filter	
36058 D		X				Absorbing pads					
36058 D Zincrement		X				Absorbing pads					
38053 I			X		X			X	Clarifier	Vacuum Filtration	
40064 O	X				X			NaOH & coagulent	Settling Tank (ineffective)		
46050 D								X	Settling Basin		

TABLE V-33
EFFLUENT POLLUTANTS (mg/l)
STEEL SUBCATEGORY

ID NUMBERS (day)		11055 (1)	11058 (1)	11058 (2)	12052 (2)	12052 (3)	36056 (1)	36056 (2)
	Flow Liters/m^2	1.514	1.884	1.909	9.63	5.13	0.640	0.367
11	1,1,1-Trichloroethane	0.00	0.00	0.00	0.021		*	*
13	1,1-Dichloroethane	0.00	*	0.00	0.00			0.00
34	2,4-Dimethylphenol	0.011						0.00
39	Fluoranthene	*	0.00	0.00	0.00	0.00	0.00	*
54	Isophorone	0.560	0.00	0.00	0.00	0.00	0.00	0.00
55	Napthalene	*	0.00	0.00	*	*	0.00	0.00
65	Phenol	*						
66	Bis(2-ethylhexyl)phthalate	*	*	*	0.026	0.025	*	*
67	Butyl benzyl phthalate	0.00	0.00	*	0.00	0.00		
68	Di-N-Butyl phthalate	*	*	*	*	*		
69	Di-N-Octyl phthalate	0.00	0.00	0.00	*	0.00		
70	Diethyl phthalate	*	*	*	0.065	0.032	*	*
71	Dimethyl phthalate	0.00	0.00	*	0.00	0.00		
72	1,2-Benzanthracene	0.00	0.00	*	*	0.00		*
73	Benzo(A)pyrene	0.00	0.00	0.00	0.00	0.00		
74	3,4-Benzofluoranthene	0.00	0.00	0.00	0.00	0.00		
75	Benzo(K)fluoranthene	0.00	0.00	0.00	0.00	0.00		
76	Chrysene	0.00	0.00	*	*	0.00		*
77	Acenaphthylene	0.00	0.00	0.00	0.00	0.00		
78	Anthracene	*	0.00	*	*	0.00	*	0.025
79	1,1,2-Benzoperylene	0.00	0.00	0.00	0.00	0.00		
80	Fluorene	*	0.00	*	*	0.00		
81	Phenanthrene	*	0.00	*	*	0.00	*	0.025
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0.00		
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0.00		
84	Pyrene	*	0.00	0.00	0.00	0.00		
86	Toluene	*						
87	Trichloroethylene	0.00	0.00	0.00	0.014		*	*
118	Cadmium	0.007	0.00	0.00	≤0.002	≤0.002	0.00	0.00
119	Chromium, Total	0.180	0.350	0.960	1.480	0.137	1.594	2.911
	Chromium, Hexavalent	0.006	0.00	0.00	0.00	0.00	1.182	
120	Copper	0.015	0.007	0.00	0.008	0.007	0.012	0.330
121	Cyanide, Total	0.00	0.00	0.00	0.072	0.037		0.00
	Cyanide, Am. to Chlor.	0.00	0.00	0.00	0.026	0.035		0.00
122	Lead	0.108	0.00	0.00	0.230	0.122	0.013	0.015
124	Nickel	0.116	0.00	0.00	0.040	<0.006	0.025	<0.006
128	Zinc	0.500	0.280	2.02	12.500	7.314	0.225	0.455
	Aluminum	0.00	0.076	0.136	0.213	0.082	0.064	0.010
	Iron	0.00	0.660		8.070	7.387	0.541	1.009
	Manganese	0.00	0.00	0.038	0.016	0.159	0.024	0.192
	Phenols, Total	0.027	0.00	≤0.005	≤0.005	≤0.005	≤0.005	≤0.005
	Phosphorus	0.340					2.897	4.427
	Oil and Grease	6.400	6.000	31.0	22.920	15.420	38.118	206.027
	Total Suspended Solids	31.000	17.000	118.000	39.070	59.560	72.273	292.545
	Minimum pH	8.0	8.3	6.9	7.4	7.1	8.5	8.0
	Maximum pH	11.1	9.5	8.6	10.8	10.0	10.8	9.0
	Temperature Deg C	29.5	22.7	24.6	33.0	29.9	22.9	28.5
Treatment-In-Place								
	Cyanide Oxidation							
	Chromium Reduction	X	X	X			X	X
	Oil Skimming	X	X	X			X	X
	Solids Removal	X	X	X	X	X	X	X
	Sludge Dewatering	X	X	X			X	X

*-possibly detected but ≤ 0.010 mg/l.

TABLE V-33 'con't)
EFFLUENT POLLUTANTS (mg/l)
STEEL SUBCATEGORY

ID NUMBERS (day)		36056 (3)	36058 (1)	36058 (3)	36058 (4)	46050 (1)	46050 (2)
	Flow Liters/m^2	0.666	5.38	6.75	13.09	7.468	9.88
11	1,1,1-Trichloroethane					*	0.00
13	1,1-Dichloroethane					0.00	
34	2,4-Dimethylphenol					0.00	
39	Fluoranthene	0.00	0.00			0.00	0.00
54	Isophorone	0.00	*			0.00	0.00
55	Napthalene	*	0.00		0.00	0.00	0.00
65	Phenol					0.00	
66	Bis(2-ethylhexyl)phthalate	*	0.084		*	0.00	0.033
67	Butyl benzyl phthalate		0.00			*	0.00
68	Di-N-butyl phthalate	*	*			*	0.00
69	Di-N-octyl phthalate	0.00	0.00		*	0.00	0.00
70	Diethyl phthalate	*	0.065		*	0.106	0.016
71	Dimethyl phthalate		0.00			0.00	0.00
72	1,2-Benzanthracene	*	*			0.00	0.00
73	Benzo(A)pyrene		0.00			0.00	0.00
74	3,4-Benzofluoranthene	0.00	*			0.00	0.00
75	Benzo(K)fluoranthene	0.00	0.00			0.00	0.00
76	Chrysene	*	*			0.00	0.00
77	Acenaphthylene	0.00	0.00			0.00	0.00
78	Anthracene	*	0.015			*	0.00
79	1,1,2-Benzoperylene		0.00			0.00	0.00
80	Fluorene	*	0.00			0.00	0.00
81	Phenanthrene	*	0.015			*	0.00
82	1,2,5,6-Dibenzanthracene		0.00			0.00	0.00
83	Ideno(1,2,3-CD)pyrene		0.00			0.00	0.00
84	Pyrene	*	*			0.00	0.00
86	Toluene					0.00	
87	Trichloroethylene	*				*	0.00
118	Cadmium		0.055		0.00	0.00	0.00
119	Chromium, Total	0.739	0.012	0.048	0.047	0.172	0.070
	Chromium, Hexavalent	0.00	0.00		0.00	0.00	0.00
120	Copper	0.022	0.015	0.025	0.010	0.007	≤0.001
121	Cyanide, Total	0.001	0.00	0.00	0.00	0.047	0.009
	Cyanide, Amn. to Chlor.	0.00	0.00		0.00	0.024	0.007
122	Lead	0.007	0.00		0.00	0.042	0.021
124	Nickel	0.00	0.00	0.00	0.00	0.485	0.536
128	Zinc	0.190	0.720	0.600	0.750	3.627	3.264
	Aluminum	0.037	0.720	0.320	0.320	0.00	0.00
	Iron	0.550	2.420	2.380	2.000	0.484	0.341
	Manganese	0.057	0.160	0.160	0.098	0.569	0.565
	Phenols, Total	0.002	0.013	*	*	*	0.008
	Phosphorus	6.373	12.100	15.800	6.100	4.557	
	Oil and Grease	183.155	0.00	107.000	8.800	20.116	10.884
	Total Suspended Solids	102.727	124.000			6.683	6.878
	Minimum pH	8.0	2.0	2.7	2.7	6.7	6.7
	Maximum pH	8.9	9.1	10.7	10.7	7.3	7.3
	Temperature Deg C	25.0	28.0	26.0	26.0	28.0	27.0

Treatment-In-Place	36056 (3)	36058 (1)	36058 (3)	36058 (4)	46050 (1)	46050 (2)
Cyanide Oxidation						
Chromium Reduction	X					X
Oil Skimming	X	X	X	X		
Solids Removal	X	X	X	X	X	X
Sludge Dewatering	X					X

*-possibly detected but ≤ 0.010 mg/l.

TABLE V-34
EFFLUENT POLLUTANTS (mg/m^2)
STEEL SUBCATEGORY

ID	NUMBERS (day)	11055 (1)	11058 (1)	11058 (2)	12052 (2)	12052 (3)	36056 (1)	36056 (2)
	Flow Liters/m^2	1.514	1.884	1.909	9.63	5.13	0.640	0.367
11	1,1,1-Trichloroethane	0.00	0.00	0.00	0.202		*	*
13	1,1-Dichloroethane	0.00	*	0.00	0.00			0.00
34	2,4-Dimethylphenol	0.017						0.00
39	Fluoranthene	*	0.00	0.00	0.00	0.00	0.00	*
54	Isophorone	0.848	0.00	0.00	0.00	0.00	0.0 0	0.00
55	Napthalene	*	0.00	0.00	*	*	0.00	0.00
65	Phenol	*						
66	Bis(2-ethylhexyl)phthalate	*	*	*	0.250	0.128	*	*
67	Butyl benzyl phthalate	0.00	0.00	*	0.00	0.00		
68	Di-N-Butyl phthalate	*	*	*	*	*		
69	Di-N-Octyl phthalate	0.00	0.00	0.00	*	0.00		
70	Diethyl phthalate	*	*	*	0.819	0.164	*	*
71	Dimethyl phthalate	0.00	0.00	*	0.00	0.00		
72	1,2-Benzanthracene	0.00	0.00	*	*	0.00		*
73	Benzo(A)pyrene	0.00	0.00	0.00	0.00	0.00		
74	3,4-Benzofluoranthene	0.00	0.00	0.00	0.00	0.00		
75	Benzo(K)fluoranthene	0.00	0.00	0.00	0.00	0.00		
76	Chrysene	0.00	0.00	*	*	0.00		*
77	Acenaphthylene	0.00	0.00	0.00	0.00	0.00		
78	Anthracene	*	0.00	*	*	0.00	*	0.009
79	1,1,2-Benzoperylene	0.00	0.00	0.00	0.00	0.00		
80	Fluorene	*	0.00	*	*	0.00		
81	Phenanthrene	*	0.00	*	*	0.00	*	0.009
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0.00		
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0.00		
84	Pyrene	*	0.00	0.00	0.00	0.00		
86	Toluene	*						
87	Trichloroethylene	0.00	0.00	0.00	0.135		*	*
118	Cadmium	0.011	0.00	0.00	*	*	0.00	0.00
119	Chromium, Total	0.273	0.659	1.833	14.25	0.730	1.020	1.068
	Chromium, Hexavalent	0.009	0.00	0.00	0.00	0.00	0.756	
120	Copper	0.023	0.013	0.00	0.077	0.036	0.008	0.121
121	Cyanide, Total	0.00	0.00	0.00	0.693	0.190		0.00
	Cyanide, Amn. to Chlor.	0.00	0.00	0.00	0.250	0.180		0.00
122	Lead	0.164	0.00	0.00	2.215	0.626	0.008	0.006
124	Nickel	0.176	0.00	0.00	0.385	*	0.016	*
128	Zinc	0.757	0.528	3.856	120.4	37.52	0.144	0.167
	Aluminum	0.00	0.143	0.260	2.051	0.421	0.041	0.004
	Iron	0.00	1.243		77.7	37.90	0.346	0.370
	Manganese	0.00	0.00	0.073	0.154	0.816	0.015	0.070
	Phenols, Total	0.041	0.00	*	*	*	*	*
	Phosphorus	0.515			0.00		1.854	1.625
	Oil and Grease	9.69	11.30	59.2	220.7	79.1	24.40	75.6
	Total Suspended Solids	46.93	32.03	225.3	376.2	305.5	46.26	107.4
	Minimum pH	8.0	8.3	6.9	7.4	7.1	8.5	8.0
	Maximum pH	11.1	9.5	8.6	10.8	10.0	10.8	9.0
	Temperature Deg C	29.5	22.7	24.6	33.0	29.9	22.9	28.5

Treatment-In-Place							
Cyanide Oxidation							
Chromium Reduction	X	X	X			X	X
Oil Skimming	X	X	X			X	X
Solids Removal	X	X	X	X	X	X	X
Sludge Dewatering	X	X	X			X	X

*-possibly detected but below the detection limit.

TABLE V-34 (Con't)
EFFLUENT POLLUTANTS (mg/m^2)
STEEL SUBCATEGORY

ID	NUMBERS (day)	36056 (3)	36058 (1)	36058 (3)	36058 (4)	46050 (1)	46050 (2)
	Flow Liters/m^2	0.666	5.38	6.75	13.09	7.468	9.88
11	1,1,1-Trichloroethane					*	0.00
13	1,1-Dichloroethane					0.00	
34	2,4-Dimethylphenol					0.00	
39	Fluoranthene	0.00	0.00			0.00	0.00
54	Isophorone	0.00	*			0.00	0.00
55	Napthalene	*	0.00		0.00	0.00	0.00
65	Phenol					0.00	
66	Bis(2-ethylhexyl)phthalate	*	0.452		*	0.00	0.326
67	Butyl benzyl phthalate		0.00			*	0.00
68	Di-N-Butyl phthalate	*	*			*	0.00
69	Di-N-Octyl phthalate	0.00	0.00		*	0.00	0.00
70	Diethyl phthalate	*	0.350		*	0.792	0.158
71	Dimethyl phthalate		0.00			0.00	0.00
72	1,2-Benzanthracene	*	*			0.00	0.00
73	Benzo(A)pyrene		0.00			0.00	0.00
74	3,4-Benzofluoranthene	0.00	*			0.00	0.00
75	Benzo(K)fluoranthene	0.00	0.00			0.00	0.00
76	Chrysene	*	*			0.00	0.00
77	Acenaphthylene	0.00	0.00			0.00	0.00
78	Anthracene	*	0.081			*	0.00
79	1,1,2-Benzoperylene		0.00			0.00	0.00
80	Fluorene	*	0.00			0.00	0.00
81	Phenanthrene	*	0.081			*	0.00
82	1,2,5,6-Dibenzanthracene		0.00			0.00	0.00
83	Ideno(1,2,3-CD)pyrene		0.00			0.00	0.00
84	Pyrene	*	*			0.00	0.00
86	Toluene					0.00	
87	Trichloroethylene	*				*	0.00
118	Cadmium		0.296		0.00	0.00	0.00
119	Chromium, Total	0.492	0.065	0.324	0.615	1.284	0.692
	Chromium, Hexavalent	0.00	0.00		0.00	0.00	0.00
120	Copper	0.015	0.081	0.189	0.131	0.052	*
121	Cyanide, Total	0.001	0.00	0.00	0.00	0.351	0.089
	Cyanide, Am. to Chlor.	0.00	0.00		0.00	0.179	0.069
122	Lead	0.005	0.00	0.00		0.314	
124	Nickel	0.00	0.00	0.00	0.00	3.622	5.30
128	Zinc	0.127	3.874	4.05	9.82	27.9	32.25
	Aluminum	0.025	3.874	2.160	4.189	0.00	0.00
	Iron	0.366	13.2	16.07	26.18	3.615	3.369
	Manganese	0.038	0.861	1.080	1.283	4.249	5.58
	Phenols, Total	0.001	0.070	*	*	*	0.079
	Phosphorus	4.244	65.1	106.7	79.8	34.03	
	Oil and Grease	122.0	0.00	722.	115.2	150.2	107.5
	Total Suspended Solids	68.4	667.			49.91	68.0
	Minimum pH	8.0	2.0	2.7	2.7	6.7	6.7
	Maximum pH	8.9	9.1	10.7	10.7	7.3	7.3
	Temperature Deg C	25.0	28.0	26.0	26.0	28.0	27.0

Treatment-In-Place	36056 (3)	36058 (1)	36058 (3)	36058 (4)	46050 (1)	46050 (2)
Cyanide Oxidation						
Chromium Reduction	X	X	X	X	X	
Oil Skimming	X	X	X	X	X	
Solids Removal	X				X	
Sludge Dewatering	X				X	

*-possibly detected but below the detection limit.

TABLE V-35
EFFLUENT POLLUTANTS (mg/l)
GALVANIZED SUBCATEGORY

	ID NUMBER (day)	11058(1)	11058(2)	12052(1)	12052(2)	12052(3)	33056(1)	33056(2)	38053(1)	38053(2)	38053(3)	46050(3)	36058(2)
	Flow Liters/m^2	1.866	2.038	6.84	6.10	8.40	1.178	1.058	0.645	0.889	0.978	11.65	7.91
11	1,1,1-Trichloroethane	0.00	0.00			0.00	0.290	2.530	0.00	0.00	0.018	0.00	
13	1,1,-Dichloroethane	*	0.00				*						
29	11-Dichloroethylene					0.00	0.070	0.040	0.00	0.00	0.00	0.00	
30	1,2T-Dichloroethylene					0.00	*	0.019	0.00	0.00		0.00	
39	Fluoranthene	0.00	0.00		*	0.00			0.00	0.00	*	0.00	0.00
54	Isophorone	0.00	0.00		0.00	0.00	0.110		0.00	*	*	0.00	0.00
55	Napthalene	0.00	0.00		*	0.00			*	*	*	0.00	0.00
66	Bis(ethylhexyl)phthalate	*	*		0.026	0.025	0.015	*	0.053	0.038	0.036	0.020	*
67	Butyl benzyl phthalate	0.00	*			0.00		0.00	0.00	0.00	0.00	0.00	0.00
68	Di-N-Butyl phthalate	*	*		*	*	*		0.00	*	*	0.00	*
69	Di-N-Octyl phthalate	0.00	0.00		*	0.00			0.00	0.00	0.00	0.00	*
70	Diethyl phthalate	*	*		0.085	0.032	0.00	0.00	0.803	0.079	0.097	0.034	*
71	Dimethyl phthalate	0.00	*		0.00	0.00	*		0.00	0.00	0.00	0.00	0.00
72	1,2-Benzanthracene	0.00	*		*	0.00			*	*	*	0.00	*
73	Benzo(A)pyrene	0.00	0.00		0.00	0.00			0.00	0.00	0.00	0.00	0.00
74	34-Benzofluoranthene	0.00	0.00		0.00	0.00			0.00	0.00	0.00	0.00	0.00
75	Benzo(K)pyrene	0.00	0.00		0.00	0.00			0.00	0.00	0.00	0.00	0.00
76	Chrysene	0.00	*		*	0.00			*	*	*	0.00	*
77	Acenaphthylene	0.00	0.00			0.00			0.00	0.00	0.00	*	0.00
78	Anthracene	0.00	*		*	0.00			*	*	*	*	*
79	1,1,2-Benzoperylene	0.00	0.00			0.00			0.00	0.00	0.00	0.00	
80	Fluorene	0.00	*		*	0.00			*	*	*	0.00	0.00
81	Phenanthrene	0.00	*		*	0.00	*		*	*	*	*	*
82	1,2,5,6 Dibenzanthracene	0.00	0.00		0.00	0.00			0.00	0.00	0.00	0.00	0.00
83	Ideno(1,2,3-CD)pyrene	0.00	0.00		0.00	0.00			0.00	0.00	0.00	0.00	0.00
84	Pyrene	0.00	*		0.00	0.00			0.00	0.00	*	0.00	0.00
87	Trichloroethylene	0.00	0.00			0.00	0.190	3.000	0.00	0.00	0.00		
118	Cadmium	0.00	0.00	0.203	<0.002	<0.002	0.00	0.042	0.00	0.00	0.00	0.00	0.00
119	Chromium, Total	0.350	0.960	17.406	1.480	0.137	0.500	0.100	0.275	3.350	0.445	0.011	0.047
	Chromium, Hexavalent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
120	Copper	0.007	0.011	0.011	0.008	0.007	0.00	0.00	0.004	0.00	0.00	0.001	0.010
121	Cyanide, Total	0.00	0.00	0.091	0.072	0.037	0.090	0.090	0.00	0.00	0.00	0.041	0.00
	Cyanide Amn. to Chlor.	0.00	0.00	0.091	0.026	0.035	0.050	0.00	0.00	0.00	0.00	0.021	0.00
122	Lead	0.00	0.00	0.505	0.233	0.122	0.00	0.00	0.00	0.00	0.00	0.00	0.00
124	Nickel	0.00	0.00	0.762	0.040	0.003	0.070	0.00	0.00	0.008	0.036	0.475	0.00
128	Zinc	0.280	2.020	63.260	12.500	7.314	0.300	0.091	0.560	4.280	3.842	0.440	0.750
	Aluminum	0.076	0.136	2.130	0.213	0.082	2.000	0.680	0.540	0.240	3.121	0.00	0.320
	Iron	0.660		7.627	8.070	7.387	1.000	1.750	0.310	0.160	0.290	0.170	2.000
	Manganese	0.00	0.038	0.115	0.016	0.159	0.070	0.091	0.009	0.00	0.012	0.560	0.098
	Phenols, Total	0.00	*	0.019	0.002	*	*	*	0.067	0.015	0.017	*	*
	Phosphorus					1.050	10.100	12.000		1.690	1.670	1.003	*
	Oil & Grease	6.000	31.000	28.100	22.920	15.420	18.000	21.000	12.400	13.000	5.600	3.730	8.800
	Total Suspended Solids	17.000	118.000	440.680	39.070	59.560	6.000	20.000	30.000	27.000	24.000	6.010	
	Minimum pH	8.3	6.9	7.0	7.4	6.8	7.5	7.5	7.1	6.5	4.3	6.7	3.9
	Maximum pH	9.5	8.6	10.7	11.6	11.5	7.5	7.5	11.5	9.1	9.4	7.3	9.2
	Temperature Deg C	22.7	24.6	37.6	37.9	40.0	28.0	28.0	37.0	38.0	40.0	26.0	23.0

Treatment-In-Place	11058(1)	11058(2)	12052(1)	12052(2)	12052(3)	33056(1)	33056(2)	38053(1)	38053(2)	38053(3)	46050(3)	36058(2)
Cyanide Oxidation												
Chromium Reduction					X	X	X	X	X	X		
Oil Skimming		X		X	X	X						
Solids Removal		X		X		X	X					
Sludge Dewater		X	X	X	X			X	X	X	X	X

*-possibly detectd but ≤0.010 mg/l.

TABLE V-36
EFFLUENT POLLUTANTS (mg/m^2)
GALVANIZED SUBCATEGORY

ID NUMBER (day)		11058(1)	11058(2)	12052(1)	12052(2)	12052(3)	33056(1)	33056(2)	38053(1)	38053(2)	38053(3)	46050(3)	36058(2
	Flow Liters/m^2	1.866	2.038	6.84	6.10	8.40	1.178	1.058	0.645	0.889	0.978	11.65	7.91
11	1,1,1-Trichloroethane	0.00	0.00		0.128	0.00	0.342	2.677	0.00	0.00	0.018	0.00	
13	1,1,-Dichloroethane	*					*						
29	11-Dichloroethylene					0.00	0.082	0.042	0.00	0.00	0.00	0.00	
30	1,2T-Dichloroethylene					0.00	*	0.020	0.00	0.00		0.00	
39	Fluoranthene	0.00	0.00		*	0.00			0.00	0.00	*	0.00	0.00
54	Isophorone	0.00	0.00		0.00	0.00	0.130		0.00	*	*	0.00	0.00
55	Napthalene	0.00	0.00		*	0.00			*	*	*	0.00	0.00
66	Bis(ethylhexyl)phthalate	*	*		0.159	0.210	0.018	*	0.034	0.034	0.035	0.233	*
67	Butyl benzyl phthalate	0.00	*			0.00		0.00	0.00	0.00	0.00		0.00
68	Di-N-butyl phthalate	*	*		*	*	*		0.00	*	*	0.00	*
69	Di-N-octyl phthalate	0.00	0.00		*	0.00			0.00	0.00	0.00	0.00	*
70	Diethyl phthalate	*	*		0.519	0.269	0.00	0.00	0.518	0.070	0.095	0.396	*
71	Dimethyl phthalate	0.00	*		0.00	0.00	*		0.00	0.00	0.00	0.00	0.00
72	1,2-Benzanthracene	0.00	*		*	0.00			*	*	*	0.00	*
73	Benzo(A)pyrene	0.00	0.00		0.00	0.00			0.00	0.00	0.00	0.00	0.00
74	34-Benzofluoranthene	0.00	0.00		0.00	0.00			0.00	0.00	0.00	0.00	0.00
75	Benzo(K)pyrene	0.00	0.00		0.00	0.00			0.00	0.00	0.00	0.00	0.00
76	Chrysene	0.00	*		*	0.00			*	*	*	0.00	*
77	Acenaphthylene	0.00	0.00			0.00			0.00	0.00	0.00	*	0.00
78	Anthracene	0.00	*		*	0.00			*	*	*	*	*
79	1,1,2-Benzoperylene	0.00	0.00			0.00			0.00	0.00	0.00	0.00	
80	Fluorene	0.00	*		*	0.00			*	*	*	0.00	0.00
81	Phenanthrene	0.00	*		*	0.00	*		*	*	*	*	*
82	1,2,5,6 Dibenzanthracene	0.00	0.00		0.00	0.00			0.00	0.00	0.00	0.00	0.00
83	Ideno(1,2,3-CD)pyrene	0.00	0.00		0.00	0.00			0.00	0.00	0.00	0.00	0.00
84	Pyrene	0.00	*		0.00	0.00			0.00	0.00	*	0.00	0.00
87	Trichloroethylene	0.00	0.00			0.00	0.224	3.174	0.00	0.00	0.00		
118	Cadmium	0.00	0.00	1.389	*	*	0.00	0.044	0.00	0.00	0.00	0.00	0.00
119	Chromium, Total	0.653	1.956	119.1	9.03	1.151	0.589	0.106	0.177	2.978	0.435	0.128	0.372
	Chromium, Hexavalent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
120	Copper	0.013	0.022	0.075	0.049	0.059	0.00	0.00	0.003	0.00	0.00	0.012	0.079
121	Cyanide, Total	0.00	0.00	0.622	0.439	0.311	0.105	0.095	0.00	0.00	0.00	0.478	0.00
	Cyanide Am. to Chlor.	0.00	0.00	0.622	0.159	0.294	0.059	0.00	0.00	0.00	0.00	0.295	0.00
122	Lead	0.00	0.00	3.454	1.421	1.025	0.00	0.00	0.00	0.00	0.00	0.00	0.00
124	Nickel	0.00	0.00	5.212	0.244	0.025	0.082	0.00	0.00	0.007	0.035	5.53	0.00
128	Zinc	0.522	4.117	432.7	76.25	61.4	0.353	0.096	0.361	3.805	3.757	5.13	5.93
	Aluminum	0.142	0.277	14.57	1.299	0.689	2.356	0.719	0.348	0.213	3.052	0.00	2.531
	Iron	1.232		52.2	49.23	62.1	1.178	1.852	0.200	0.142	0.294	1.981	15.82
	Manganese	0.00	0.077	0.787	0.098	1.336	0.082	0.096	0.006	0.00	0.012	6.52	0.775
	Phenols, Total	0.00	0.00	0.130	0.012	*	*	*	0.043	0.013	0.017	*	*
	Phosphorus					8.82	11.90	12.70	0.677	1.502	1.633	11.68	*
	Oil & Grease	11.20	63.2	192.2	139.8	129.5	21.20	22.22	8.00	11.56	5.48	43.45	69.6
	Total Suspended Solids	31.72	240.5	3014.	238.3	500.	7.07	21.16	19.35	24.00	23.47	70.02	
	Minimum pH	8.3	6.9	7.3	7.4	6.8	7.5	7.5	7.1	6.5	4.3	6.7	3.9
	Maximum pH	9.5	8.6	10.7	11.6	11.5	7.5	7.5	11.5	9.1	9.4	7.3	9.2
	Temperature Deg C	22.7	24.6	37.7	37.9	40.0	28.0	28.0	37.0	38.0	40.0	26.0	23.0

Treatment-in-Place	11058(1)	11058(2)	12052(1)	12052(2)	12052(3)	33056(1)	33056(2)	38053(1)	38053(2)	38053(3)	46050(3)	36058(2
Cyanide Oxidation												
Chromium Reduction	X	X				X	X	X	X	X	X	
Oil Skimming	X	X				X	X					
Solids Removal	X	X	X	X	X	X	X	X	X	X	X	
Sludge Dewater	X	X						X	X	X	X	

*- possibly detected but below the detection limit.

TABLE V-37
EFFLUENT POLLUTANTS (mg/l)
ALUMINUM SUBCATEGORY

ID	NUMBER (day)	01054(1)	01054(2)	01054(3)	01057(1)	01057(2)	01057(3)	13029(1)	13029(2)	13029(3)	15436(1)
	Flow Liters/m^2	0.451	0.364	0.300	5.45	6.26	5.62	5.81	2.419	2.378	0.880
39	Fluoranthene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
54	Isophorone	0.00	0.00	0.00	0.00	0.00	0.00		0.00	*	
55	Napthalene	0.00	0.00	0.00	0.00	0.00	*		*	*	
66	Bis(ethylhexyl)phthalate	0.025	*	*	*	0.040	*		0.025	0.017	0.00
67	Butyl benzyl phthalate	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
68	Di-N-butyl phthalate	0.00	0.00	0.00	0.00	0.00	0.00		*	0.00	0.00
69	Di-N-octyl phthalate	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
70	Diethyl phthalate	0.300	0.00	0.025	0.194	0.035	0.190	0.028	0.013		
71	Dimethyl phthalate	0.00	0.00	0.00	*		*		0.00	0.00	
72	1,2-Benzanthracene	0.00	0.00	0.00	0.00	0.00	0.00		0.00		
73	Benzo(A)pyrene	*	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
74	34-Benzofluoranthene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
75	Benzo(K)fluoranthene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
76	Chrysene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
77	Acenaphthylene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
78	Anthracene	0.00	*	0.00	0.00	0.00	0.00		*	0.00	
79	1,1,2-Benzoperylene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
80	Fluorene	*	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
81	Phenanthrene	0.00	*	0.00	0.00	0.00	0.00		*	0.00	
82	1,2,5,6 Dibenzanthracene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
84	Pyrene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
118	Cadmium	0.00	0.00	0.00	0.00	0.004	0.008	0.00	0.00	0.00	
119	Chromium, Total	0.570	0.310	0.100	≤0.003	≤0.003	0.00	1.417	1.258	4.707	0.00
	Chromium, Hexavalent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
120	Copper	0.002	0.00	0.006	0.00	0.00	0.00	0.005	0.008	0.009	0.00
121	Cyanide, Total	0.039	0.032	0.006	0.017	0.016	0.010	0.00	0.00	0.00	2.000
	Cyanide Amn. to Chlor.	0.039	0.032	0.006			0.00	0.00	0.00	0.00	0.940
122	Lead	0.042	0.060	0.065	0.00	0.00	0.00	0.00	0.00	0.00	0.00
124	Nickel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
128	Zinc	0.300	1.780	3.220	0.234	0.218	0.724	0.141	0.083	0.129	0.00
	Aluminum	1.980	1.680	1.680	3.282	7.231	7.269	1.929	2.471	5.942	0.00
	Fluorides	72.000	66.000	48.000	2.137	2.663	2.051	17.501	22.343	21.995	38.000
	Iron	0.580	0.025	0.028	0.129	0.155	0.091	0.111	0.060	0.109	0.00
	Manganese	0.120	0.085	0.210	0.007	0.007	0.004	0.003	0.007	0.015	0.00
	Phenols, Total	0.028	0.008	0.016	0.031	0.036	0.003	0.00	0.078	0.00	0.00
	Phosphorus	0.340	1.940	0.410	0.00	0.008	0.00	0.928	0.752	2.012	1.130
	Oil & Grease	2.000	6.000	3.000	3.627	4.294	9.885	4.609	12.311	6.750	4.800
	Total Suspended Solids	103.000	97.000	13.000	2.652	13.993	9.197	21.944	18.751	49.479	158.000
	Minimum pH	6.9	7.0	7.8	6.4	6.5	6.3	7.7	7.7	7.7	7.2
	Maximum pH	7.9	8.1	8.2	8.4	8.4	8.5	8.6	8.7	8.5	9.0
	Temperature Deg C	29.8	29.6	28.9	30.4	38.6	37.9	26.6	27.0	27.7	31.9

Treatment-In-Place										
Cyanide Oxidation										
Chromium Reduction	X	X	X	X	X	X	X	X	X	X
Oil Skimming										
Solids Removal	X	X	X	X	X	X	X	X	X	
Sludge Dewater	X	X	X				X			

*-Possibly detected by ≤ 0.010 mg/l

TABLE V-38
EFFLUENT POLLUTANTS (mg/m^2)
ALUMINUM SUBCATEGORY

ID NUMBER (day)		01054(1)	01054(2)	01054(3)	01057(1)	01057(2)	01057(3)	13029(1)	13029(2)	13029(3)	15436(1)
	Flow Liters/m^2	0.451	0.364	0.300	5.45	6.26	5.62	5.81	2.419	2.378	0.880
39	Fluoranthene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
54	Isophorone	0.00	0.00	0.00	0.00	0.00	0.00		0.00	*	
55	Napthalene	0.00	0.00	0.00	0.00	0.00	*		*	*	
66	Bis(ethylhexyl)phthalate	0.011	*	*	*	0.250	*		0.060	0.040	0.00
67	Butyl benzyl phthalate	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
68	Di-N-butyl phthalate	0.00	0.00	0.00	0.00	0.00	0.00		*	0.00	0.00
69	Di-N-octyl phthalate	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
70	Diethyl phthalate	0.135	0.00	0.008	1.057	0.219	1.068	0.163	0.031		
71	Dimethyl phthalate	0.00	0.00	0.00	*		*		0.00	0.00	
72	1,2-Benzanthracene	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00
73	Benzo(A)pyrene	*	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
74	34-Benzofluoranthene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
75	Benzo(K)fluoranthene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
76	Chrysene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
77	Acenaphthylene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
78	Anthracene	0.00	*	0.00	0.00	0.00	0.00		*	0.00	
79	1,1,2-Benzoperylene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
80	Fluorene	*	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
81	Phenanthrene	0.00	*	0.00	0.00	0.00	0.00		*	0.00	
82	1,2,5,6 Dibenzanthracene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
83	Ideno(1,2,3-CD)pyrene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
84	Pyrene	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
118	Cadmium	0.00	0.00	0.00	0.00	0.025	0.045	0.00	0.00	0.00	
119	Chromium, Total	0.257	0.113	0.030	*	*	0.00	8.23	3.043	11.19	0.00
	Chromium, Hexavalent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
120	Copper	0.001	0.00	0.002	0.00	0.00	0.00	0.029	0.019	0.021	0.00
121	Cyanide, Total	0.018	0.012	0.002	0.093	0.100	0.056	0.00	0.00	0.00	1.760
	Cyanide Amn. to Chlor.	0.018	0.012	0.002			0.00	0.00	0.00	0.00	0.827
122	Lead	0.019	0.022	0.020	0.00	0.00	0.00	0.00	0.00	0.00	0.00
124	Nickel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
128	Zinc	0.135	0.648	0.966	1.275	1.365	4.068	0.819	0.201	0.307	0.00
	Aluminum	0.893	0.612	0.504	17.89	45.27	40.85	11.21	5.98	14.13	0.00
	Fluorides	32.47	24.02	14.40	11.65	16.67	11.53	101.7	54.05	52.30	33.44
	Iron	0.262	0.009	0.008	0.703	0.970	0.511	0.645	0.145	0.259	0.00
	Manganese	0.054	0.031	0.063	0.038	0.044	0.022	0.017	0.017	0.036	0.00
	Phenols, Total	0.013	0.003	0.005	0.169	0.225	0.017	0.00	0.189	0.00	0.00
	Phosphorus	0.153	0.706	0.123	0.00	0.050	0.00	5.392	1.819	4.785	0.994
	Oil & Grease	0.902	2.184	0.900	19.77	26.88	55.6	26.8	29.78	16.05	4.224
	Total Suspended Solids	46.45	35.31	3.900	14.45	87.60	51.7	127.5	45.36	117.7	139.0
	Minimum pH	6.9	7.0	7.8	6.4	6.5	6.3	7.7	7.7	7.7	7.2
	Maximum pH	7.9	8.1	8.2	8.4	8.4	8.5	8.6	8.7	8.5	9.0
	Temperature Deg C	29.8	29.6	28.9	30.4	38.6	37.9	26.6	27.0	27.7	31.9

Treatment-In-Place	01054(1)	01054(2)	01054(3)	01057(1)	01057(2)	01057(3)	13029(1)	13029(2)	13029(3)	15436(1)
Cyanide Oxidation										
Chromium Reduction	X	X	X	X	X	X	X	X	X	X
Oil Skimming										
Solids Removal	X	X	X	X	X	X	X	X	X	
Sludge Dewater	X	X	X				X			

* Possibly detected but below the detection limit.

SECTION VI

SELECTION OF POLLUTANT PARAMETERS

Section V presented pollutant parameters to be examined for possible regulation along with data from plant sampling visits and subsequent chemical analysis. Priority, non-conventional, and conventional pollutant parameters were selected for verification according to a specified rationale.

This section discusses each of the pollutant parameters selected for verification analysis. The selected priority pollutant parameters are discussed in numerical order, followed by non-conventional pollutants and then conventional pollutant parameters, each in alphabetical order.

Finally, the pollutant parameters selected for consideration for specific regulation and those dropped from further consideration in each subcategory are set forth. The rationale for that selection is also presented.

VERIFICATION PARAMETERS

Table V-5 (page 77) lists the pollutant parameters selected for verification sampling and analysis in the coil coating point source category. The subcategory for each is designated.

The following discussion provides information about: where the pollutant comes from - whether it is a naturally occurring element, processed metal, or manufactured compound; general physical properties and the form of the pollutants; toxic effects of the pollutant in humans and other animals; and behavior of the pollutant in POTW at the concentrations that might be expected from industrial discharges. Specific literature relied upon for the following discussion is listed in Section XV. Particular weight has been given to documents generated by the EPA Criteria and Standards Division and Monitoring and Data Support Division.

1,1,1-Trichloroethane(11). 1,1,1-Trichloroethane is one of the two possible trichloroethanes. It is manufactured by hydrochlorinating vinyl chloride to 1,1-dichloroethane which is then chlorinated to the desired product. 1,1,1-Trichloroethane is a liquid at room temperature with a vapor pressure of 96 mm Hg at 20°C and a boiling point of 74°C. Its formula is CCl_3CH_3. It is slightly soluble in water (0.48 g/l) and is very soluble in organic solvents. U.S. annual production is greater than one-third of a million tons.

1,1,1-Trichloroethane is used as an industrial solvent and degreasing agent.

Most human toxicity data for 1,1,1-trichloroethane relates to inhalation and dermal exposure routes. Limited data are available for determining toxicity of ingested 1,1,1-trichloroethane, and those data are all for the compound itself not solutions in water. No data are available regarding its toxicity to fish and aquatic organisms. For the protection of human health from the toxic properties of 1,1,1-trichloroethane ingested through the consumption of water and fish, the ambient water criterion is 18.4 mg/l. The criterion is based on bioassay for possible carcinogenicity.

No detailed study of 1,1,1-trichloroethane behavior in POTW is available; however, it has been demonstrated that none of the organic priority pollutants of this type can be broken down by biological treatment processes as readily as fatty acids, carbohydrates, or proteins.

Biochemical oxidation of many of the organic priority pollutants has been investigated in laboratory scale studies at concentrations higher than commonly expected in municipal wastewater. General observations relating molecular structure to ease of degradation have been developed for all of these pollutants. The conclusion reached by study of the limited data is that biological treatment produces a moderate degree of degradation of 1,1,1-trichloroethane. No evidence is available for drawing conclusions about its possible toxic or inhibitory effect on POTW operation; however, for degradation to occur, a fairly constant input of the compound would be necessary.

Its water solubility would allow 1,1,1-trichloroethane, present in the influent and not biodegradable, to pass through a POTW into the effluent. One factor which has received some attention, but no detailed study, is the volatilization of the lower molecular weight organics from POTW. If 1,1,1-trichloroethane is not biodegraded, it will volatilize during aeration processes in the POTW.

1,1-Dichloroethane(13). 1,1-Dichloroethane, also called ethylidene dichloride and ethylidene chloride, is a colorless liquid manufactured by reacting hydrogen chloride with vinyl chloride in 1,1-dichloroethane solution in the presence of a catalyst; however, it is reportedly not manufactured commercially in the U.S. 1,1-dichloroethane boils at 57°C and has a vapor pressure of 182 mm Hg at 20°C. It is slightly soluble in water (5.5 g/l at 20°C) and very soluble in organic solvents.

1,1-Dichloroethane is used as an extractant for heat-sensitive substances and as a solvent for rubber and silicone grease.

1,1-Dichloroethane is less toxic than its isomer (1,2-dichloroethane) but its use as an anesthetic has been discontinued because of its marked excitation of the heart. It causes central nervous system depression in humans. There are insufficient data to derive an ambient water criteria for 1,1-dichloroethane. There are insufficient data to evaluate adverse effects of 1,1-dichloroethane on organic life.

Data on the behavior of 1,1-dichloroethane in POTW are not available. Many of the organic priority pollutants have been investigated, at least in laboratory scale studies, at concentrations higher than those expected to be contained by most municipal wastewaters. General observations have been developed relating molecular structure to ease of degradation for all of the organic priority pollutants. The conclusion reached by study of the limited data is that 1,1-dichloroethane will be biochemically oxidized to a lesser extent than domestic sewage by biochemical treatment in a POTW.

The high vapor pressure of 1,1-dichloroethane is expected to result in volatilization of some of the compound from aerobic processes in POTW. Its water solubility will result in some of the 1,1-dichloroethane which enters the POTW leaving in the effluent from the POTW.

1,1-Dichloroethylene(29). 1,1-Dichloroethylene (1,1-DCE), also called vinylidene chloride, is a clear colorless liquid manufactured by dehydrochlorination of 1,1,2-trichloroethane. 1,1-DCE has the formula CCl_2CH_2. It has a boiling paint of 32°C, and a vapor pressure of 591 mm Hg at 25°C. 1,1-DCE is slightly soluble in water (2.5 mg/l) and is soluble in many organic solvents. U.S. production is in the range of hundreds of thousands of tons annually.

1,1-DCE is used as a chemical intermediate and for copolymer coatings or films. It may enter the wastewater of an industrial facility as the result of decomposition of 1,1,1-trichloroethylene used in degreasing operations, or by migration from vinylidene chloride copolymers exposed to the process water.

Human toxicity of 1,1-DCE has not been demonstrated, although it is a suspected human carcinogen. Mammalian toxicity studies have focused on the liver and kidney damage produced by 1,1-DCE. Various changes occur in those organs in rats and mice ingesting 1,1-DCE.

For the maximum protection of human health from the potential carcinogenic effects of exposure to 1,1-dichloroethylene through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. The concentration of 1,1-DCE estimated to result in an additional lifetime cancer risks of 10^{-4}, 10^{-5}, and 10^{-6} are 3.3 x 10^{-6} mg/l, 3.3 x 10^{-7} mg/l, and 3.3 x 10^{-4} mg/l. If contaminated organisms alone are consumed excluding the consumption of water, the water concentration should be less than 0.019 mg/l to keep the lifetime cancer risk below 10^{-5}.

Under laboratory conditions, dichloroethylenes have been shown to be toxic to fish. Limited acute and chronic toxicity data for aquatic life show that adverse effects occur at concentrations higher than those cited for human health risks. The primary effect of acute toxicity of the dichloroethylenes is depression of the central nervous system. The octanol/water partition coefficident of 1,1-DCE indicates it should not accumulate significantly in animals.

The behavior of 1,1-DCE in POTW has not been studied. However, its very high vapor pressure is expected to result in release of significant percentages of this material to the atmosphere in any treatment involving aeration. Degradation of dichloroethylene in air is reported to occur, with a half-life of 8 weeks.

Biochemical oxidation of many of the organic priority pollutants has been investigated in laboratory-scale studies at concentrations higher than would normally be expected in municipal wastewaters. General observations relating molecular structure to ease of degradation have been developed for all of these pollutants. The conclusion reached by study of the limited data is that biological treatment in POTW produces little or no biochemical oxidation of 1,1-dichloroethylene. No evidence is available for drawing conclusions about the possible toxic or inhibitory effect of 1,1-DCE on POTW operation. Because of water solubility, 1,1-DCE which is not volatilized or degraded is expected to pass through POTW. Very little 1,1-DCE is expected to be found in sludge from POTW.

1,2-trans-Dichloroethylene(30). 1,1-trans-Dichloroethylene (trans-1,2-DCE) is a clear, colorless liquid with the formula CHClCHCl. Trans-1,2-DCE is produced in mixture with the cis-isomer by chlorination of acetylene. The cis-isomer has distinctly different physical properties. Industrially, the mixture is used rather than the separate isomers. Trans-1,2-DCE has a boiling point of 48°C, and a vapor pressure of 324 mm Hg at 25°C.

The principal use of 1,2-dichloroethylene (mixed isomers) is to produce vinyl chloride. It is used as a lead scavenger in gasoline, general solvent, and for synthesis of various other organic chemicals. When it is used as a solvent, trans-1,2-DCE can enter wastewater streams.

For the maximum protection of human health from the potential effects of exposure to 1,2-trans-dichloroethylene through ingestion of water and contaminated aquatic organisms, the ambient water concentrations is zero. Concentrations of 1,2-trans-dichloroethylene estimated to result in additional lifetime cancer risk levels of 10^{-7}, 10^{-6}, and 10^{-5} are 3.3×10^{-6} mg/l, $3.3\ 10^{-5}$ mg/l, and 3.3×10^{-4} mg/l, respectively. If contaminated aquatic organisms alone are consumed excluding the consumption of water, the water concentration should be less than 0.018 mg/l to keep the lifetime cancer risk below 10^{-5}. Limited acute and chronic toxicity data for freshwater aquatic life show that adverse effects occur at concentrations higher than those cited for human health risks.

The behavior of trans-1,2-DCE in POTW has not been studied. However, its high vapor pressure is expected to result in release of significant percentage of this compound to the atmosphere in any treatment involving aeration. Degradation of the dichloroethylenes in air is reported to occur, with a half-life of 8 weeks.

Biochemical oxidation of many of the organic priority pollutants has been investigated in laboratory scale studies at concentrations higher than would normally be expected in municipal wastewater. General observations relating molecular structure to ease of degradation have been developed for all of these pollutants. The conclusion reached by the study of the limited data is that biological treatment in POTW produces little or no biochemical oxidation of 1,2-trans-dichloroethylene. No evidence is available for drawing conclusions about the possible toxic or inhibitory effect of 1,2-trans-dichloroethylene on POTW operation. It is expected that its low molecular weight and degree of water solubility will result in trans-1,2-DCE passing through a POTW to the effluent if it is not degraded or volatilized. Very little trans-1,2-DCE is expected to be found in sludge from POTW.

2,4-Dimethylphenol(34). 2,4-Dimethylphenol (2,4-DMP), also called 2,4-xylenol, is a colorless, crystalline solid at room temperature (25°C), which melts at 27 to 28°C. 2,4-DMP is slightly soluble in water and, as a weak acid, is soluble in alkaline solutions. Its vapor pressure is less than 1 mm Hg at room temperature.

2,4-DMP is a natural product, occurring in coal and petroleum sources. It is used commercially as a intermediate for manufacture of pesticides, dystuffs, plastics and resins, and surfactants. It is found in the water runoff from asphalt surfaces. It can find its way into the wastewater of a manufacturing plant from any of several adventitious sources.

Analytical procedures specific to this compound are used for its identification and quantification in wastewaters. This compound does not contribute to "Total Phenol" determined by the 4-aminoantipyrene method.

Three methylphenol isomers (cresols) and six dimethylphenol isomers (xylenols) generally occur together in natural products, industrial processes, commercial products, and phenolic wastes. Therefore, data are not available for human exposure to 2,4-DMP alone. In addition to this, most mammalian tests for toxicity of individual dimethylphenol isomers have been conducted with isomers other than 2,4-DMP.

In general, the mixtures of phenol, methylphenols, and dimethylphenols contain compounds which produced acute poisoning in laboratory animals. Symptoms were difficult breathing, rapid muscular spasms, disturbance of motor coordination, and assymetrical body position. In 1977, a National Academy of Science publication concluded that, "In view of the relative paucity of data on the mutagenicity, carcinogenicity, teratogenicity, and long term oral toxicity of 2,4 dimethylphenol, estimates of the effects of chronic oral exposure at low levels cannot be made with any confidence." No ambient water quality criterion can be set at this time. In order to protect public health, exposure to this compound should be minimized as soon as possible.

The behavior of 2,4-DMP in POTW has not been studied. As a weak acid its behavior may be somewhat dependent on the pH of the influent to the POTW. However, over the normal limited range of POTW pH, little effect of pH would be expected.

One study showed biological degradability of 2,4-DMP at 94.5 percent removal based on chemical oxygen demand (COD). Thus, substantial removal is expected for this compound. Another study determined that persistance of 2,4-DMP in the environment is low, thus any of the compound which remained in the sludge or passed through the POTW into the effluent would be degraded within a moderate length of time (estimated as 2 months in the report).

Fluoranthene(39). Fluoranthene (1,2-benzacenaphthene) is one of the compounds called polynuclear aromatic hydrocarbons (PAH). A pale yellow solid at room temperature, it melts at 111°C and has a negligible vapor pressure at 25°C. Water solubility is low (0.2 mg/l). Its molecular formula is $C_{16}H_{10}$.

Fluoranthene, along with many other PAH's, is found throughout the environment. It is produced by pyrolytic processing of organic raw materials, such as coal and petroleum, at high temperature (coking processes). It occurs naturally as a product of plant biosyntheses. Cigarette smoke contains fluoranthene. Although it is not used as the pure compound in industry, it has been found at relatively higher concentrations (0.002 mg/l) than most other PAH's in at least one industrial effluent. Furthermore, in a 1977 EPA survey to determine levels of PAH in U.S. drinking water supplies, none of the 110 samples analyzed showed any PAH other than fluoranthene.

Experiments with laboratory animals indicate that fluoranthene presents a relatively low degree of toxic potential from acute exposure, including oral administration. Where death occured, no information was reported concerning target organs or specific cause of death.

There is no epidemiological evidence to prove that the presence of PAH in general, and fluoranthene in particular in drinking water are related to the development of cancer. The only studies directed toward determining carcinogenicity of fluoranthene have been skin tests on laboratory animals. Results of these tests show that fluoranthene has no activity as a complete carcinogen (i.e., an agent which produces cancer when applied by itself, but exhibits significant cocarcinogenicity (i.e., in combination with a carcinogen, it increases the carcinogenic activity).

Based on the limited animal study data, and following an established procedure, the ambient water quality criterion for fluoranthene, alone, (not in combination with other PAH) is determined to be 0.042 mg/l for the protection of human health from its toxic properties.

There are no data on the chronic effects of fluoranthene on freshwater organisms. One saltwater invertebrate shows chronic toxicity at concentrations below 0.016 mg/l. For some freshwater fish species the concentrations producing acute toxicity are substantially higher, but data are very limited.

Results of studies of the behavior of fluoranthene in conventional sewage treatment processes found in POTW have been published. Removal of fluoranthene during primary sedimentation was found to be 62 to 66 percent (from an initial value of 0.00323 to 0.0435 mg/l to a final value of 0.00122 to 0.0146 mg/l), and the removal was 91 to 99 percent (final values of 0.00028 to 0.00026 mg/l) after biological purification with activated sludge processes.

A review was made of data on biochemical oxidation of many of the organic priority pollutants investigated in laboratory scale studies at concentrations higher than would normally be expected in municipal wastewater. General observations relating molecular structure to ease of degradation have been developed for all of these pollutants. The conclusion reached by study of the limited data is that biological treatment produces little or no degradation of fluoranthene. The same study, however, concludes that fluoranthene would be readily removed by filtration and oil water separation and other methods which rely on water insolubility, or adsorption on other particulate surfaces. This latter conclusion is supported by the previously cited study showing significant removal by primary sedimentation.

No studies were found on either the possible interference of fluoranthene with POTW operation, or the persistence of fluoranthene in sludges on POTW effluent waters. Several studies have documented the ubiquity of fluoranthene in the environment, but it cannot be readily determined if this results from persistance of anthropogenic fluoranthene, or from the replacement of degraded fluoranthene by natural processes such as biosynthesis in plants.

Isophorone(54). Isophorone is an industrial chemical produced in the tens of millions of pounds annually in the U.S. The chemical name for isophorone is 3,5,5-trimethyl-2-cyclohexen-1-one and it is also known as trimethyl cyclohexanone and isoacetophorone. The formula is $C_6H_5(CH_3)_3O$. Normally, it is produced as the gamma isomer; technical grades contain about 3 percent of the beta isomer (3,5-5-trimethyl-3-cyclohexen-1-one). The pure gamma isomer is a water-white liquid, with vapor pressure less than 1 mm Hg at room temperature, and a boiling point of 215.2°C. It has a camphor- or peppermint-like odor and yellows upon standing. It is slightly soluble (12 mg/l) in water and dissolves in fats and oils.

Isophorone is synthesized from acetone and is used commercially as a solvent or cosolvent for finishes, lacquers, polyvinyl and nitrocellulose resins, pesticides, herbicides, fats, oils, and gums. It is also used as a chemical feedstock.

Because isophorone is an industrially used solvent, most toxicity data are for inhalation exposure. Oral administration to laboratory animals in two different studies revealed no acute or chronic effects during 90 days, and no hematological or pathological abnormalities were reported. Apparently, no studies have been completed on the carcinogenicity of isophorone.

Isophorone does undergo bioconcentration in the lipids of aquatic organisms and fish.

Based on subacute data, the ambient water quality criterion for isophorone ingested through consumption of water and fish is set at 5.2 mg/l for the protection of human health from its toxic properties.

Studies of the effects of isophorone on fish and aquatic organisms reveal relatively low toxicity, compared to some other priority pollutants.

The behavior of isophorone in POTW has not been studied. However, the biochemical oxidation of many of the organic priority pollutants has been investigated in laboratory-scale studies at concentrations higher than would normally be expected in municipal wastewater. General observations relating molecular structure to ease of degradation have been developed for all of these pollutants. The conclusion reached by the study of the limited data is that biochemical treatment in POTW produces moderate removal of isophorone. This conclusion is consistant with the findings of an experimental study of microbiological degradation of isophorone which showed about 45 percent biooxidation in 15 to 20 days in domestic wastewater, but only 9 percent in salt water. No data were found on the persistance of isophorone in sewage sludge.

Naphthalene(55). Naphthalene is an aromatic hydrocarbon with two orthocondensed benzene rings and a molecular formula of $C_{10}H_8$. As such, it is properly classed as a polynuclear aromatic hydrocarbon (PAH). Pure naphthalene is a white crystalline solid melting at 80°C. For a solid, it has a relatively high vapor pressure (0.05 mm Hg at 20°C), and moderate water solubility (19 mg/l at 20°C). Naphthalene is the most abundant single component of coal tar. Production is more than a third of a million tons annually in the U.S. About three fourths of the production is used as feedstock for phthalic anhydride manufacture. Most of the remaining production goes into manufacture of insecticide, dystuffs, pigments, and pharmaceuticals. Chlorinated and partially hydrogenated naphthalenes are used in some solvent mixtures. Naphthalene is also used as a moth repellent.

Napthalene, ingested by humans, has reportedly caused vision loss (cataracts), hemolytic anemia, and occasionally, renal disease. These effects of naphthalene ingestion are confirmed by studies on laboratory animals. No carcinogenicity studies are available which can be used to demonstrate carcinogenic activity for naphthalene. Naphthalene does bioconcentrate in aquatic organisms.

No ambient water quality criteria have been established for protection of human health or aquatic lief; however, studies of freshwater aquatic life have shown chronic toxicty effects at 0.62 mg/l.

Only a limited number of studies have been conducted to determine the effects of naphthalene on aquatic organisms. The data from those studies show only moderate toxicity.

Naphthalene has been detected in sewage plant effluents at concentrations up to 22 µg/l in studies carried out by the U.S. EPA. Influent levels were not reported. The behavior of naphthalene in POTW has not been studied. However, recent studies have determined that naphthalene will accumulate in sediments at 100 times the concentration in overlying water. These results suggest that naphthalene will be readily removed by primary and secondary settling in POTW, if it is not biologically degraded.

Biochemical oxidation of many of the organic priority pollutants has been investigated in laboratory-scale studies at concentrations higher than would normally be expected in municipal wastewater. General observations relating molecular structure to ease of degradation have been developed for all of these pollutants. The conclusion reached by study of the limited data is that biological treatment produces a high removal by degradation of naphthalene. One recent study has shown that microorganisms can degrade naphthalene, first to a dihydro compound, and ultimately to carbon dioxide and water.

Phenol(65). Phenol, also called hydroxybenzene and carbolic acid, is a clear, colorless, hygroscopic, deliquescent, crystalline solid at room temperature. Its melting point is 43°C and its vapor pressure at room temperature is 0.35 mm Hg. It is very soluble in water (67 gm/l at 16°C) and can be dissolved in benzene, oils, and petroleum solids. Its formula is C_6H_5OH.

Although a small percent of the annual production of phenol is derived from coal tar as a naturally occuring product, most of the phenol is synthesized. Two of the methods are fusion of benzene sulfonate with sodium hydroxide, and oxidation of cumene followed by cleavage with a catalyst. Annual production in the U.S. is in excess of one million tons. Phenol is generated during distillation of wood and the microbiological decomposition of organic matter in the mammalian intestinal tract.

Phenol is used as a disinfectant, in the manufacture of resins, dyestuffs, and pharmaceuticals, and in the photo processing industry. In this discussion, phenol is the specific compound which is separated by methylene chloride extraction of an acidified sample and identified and quantified by GC/MS. Phenol also contributes to the "Total Phenols", discussed elsewhere which are determined by the 4-AAP colorimetric method.

Phenol exhibits acute and sub-acute toxicity in humans and laboratory animals. Acute oral doses of phenol in humans cause sudden collapse and unconsciousness by its action on the central nervous system. Death occurs by respiratory arrest. Sub-acute oral doses in mammals are rapidly absorbed then quickly distributed to various organs, then cleared from the body by urinary excretion and metabolism. Long term exposure by drinking phenol contaminated water has resulted in statistically significant increases in reported cases of diarrhea, mouth sores, and burning of the mouth. In laboratory animals long term oral administration at low levels produced slight liver and kidney damage. No reports were found regarding carcinogenicity of phenol administered orally - all carcinogenicity studies were skin tests.

For the protection of human health from phenol ingested through water and through contaminated aquatic organisms the concentration in water should not exceed 3.5 mg/l.

Fish and other aquatic organisms demonstrated a wide range of sensitivities to phenol concentration. However, acute toxicity values were at moderate levels when compared to other organic priority pollutants.

Data have been developed on the behavior of phenol in POTW. Phenol is biodegradable by biota present in POTW. The ability of a POTW to treat phenol-bearing influents depends upon acclimation of the biota and the constancy of the phenol concentration. It appears that an induction period is required to build up the population of organisms which can degrade phenol. Too large a concentration will result in upset or pass through in the POTW, but the specific level causing upset depends on the immediate past history of phenol concentrations in the influent. Phenol levels as high as 200 mg/l have been treated with 95 percent removal in POTW, but more or less continuous presence of phenol is necessary to maintain the population of microorganisms that degrade phenol.

Phenol which is not degraded is expected to pass thorugh the POTW because of its very high water solubility. However, in POTW where chlorination is practiced for disinfection of the POTW effluent, chlorination of phenol may occur. The products of that reaction may be priority pollutants.

The EPA has developed data on influent and effluent concentrations of total phenols in a study of 103 POTW. However, the analytical procedure was the 4-AAP method mentioned earlier and not the GC/MS method specifically for phenol. Discussion of the study, which of course includes phenol, is presented under the pollutant heading "Total Phenols."

Phthalate Esters (66-71). Phthalic acid, or 1,2-benzenedicarboxylic acid, is one of three isomeric benzenedicarboxylic acids produced by the chemical industry. The other two isomeric forms are called isophthalic and terephthalic acids. The formula for all three acids is $C_6H_4(COOH)_2$. Some esters of phthalic acid are designated as priority pollutants. They will be discussed as a group here, and specific properties of individual phthalate esters will be discussed afterwards.

Over one billion pounds of phthalic acid esters are manufactured in the U.S. annually. They are used as plasticizers - primarily in the production of polyvinyl chloride (PVC) resins. The most widely used phthalate plasticizer is bis (2-ethylhexyl) phthalate (66) which accounts for nearly one third of the phthalate esters produced. This particular ester is commonly referred to as dioctyl phthalate (DOP) and should not be confused with one of the less used esters, di-n-octyl phthalate (69), which is also used as a plasticizer. In addition to these two isomeric dioctyl phthalates, four other esters, also used primarily as plasticizers, are designated as priority pollutants. They are: butyl benzyl phthalate (67); di-n-butyl phthalate (68); diethyl phthalate (70); and dimethyl phthalate (71).

Industrially, phthalate esters are prepared from phthalic anhydride and the specific alcohol to form the ester. Some evidence is available suggesting that phthalic acid esters also may be synthesized by certain plant and animal tissues. The extent to which this occurs in nature is not known.

Phthalate esters used as plasticizers can be present in concentrations of up to 60 percent of the total weight of the PVC plastic. The plasticizer is not linked by primary chemical bonds to the PVC resin. Rather, it is locked into the structure of intermeshing polymer molecules and held by van der Waals forces. The result is that the plasticizer is easily extracted. Plasticizers are responsible for the odor associated with new plastic toys or flexible sheet that has been contained in a sealed package.

Although the phthalate esters are not soluble or are only very slightly soluble in water, they do migrate into aqueous solutions placed in contact with the plastic. Thus industrial facilities with tank linings, wire and cable coverings, tubing, and sheet flooring of PVC are expected to discharge some phthalate esters in their raw waste. In addition to their use as plasticizers, phthalate esters are used in lubricating oils and pesticide carriers. These also can contribute to industrial discharge of phthalate esters.

The accumulated data on acute toxicity in animals suggest that phthalate esters have a rather low order of toxicity. Human toxicity data are limited. It are thought that the toxic effects of the esters is most likely due to one of the metabolic products, in particular the monoester. Oral acute toxicity in animals is greater for the lower molecular weight esters than for the higher molecular weight esters.

Orally administered phthalate esters generally produced enlarging of liver and kidney, and atrophy of testes in laboratory animals. Specific esters produced enlargement of heart and brain, spleenitis, and degeneration of central nervous system tissue.

Subacute doses administered orally to laboratory animals produced some decrease in growth and degeneration of the testes. Chronic studies in animals showed similar effects to those found in acute and subacute studies, but to a much lower degree. The same organs were enlarged, but pathological changes were not usually detected.

A recent study of several phthalic esters produced suggestive but not conclusive evidence that dimethyl and diethyl phthalates have a cancer liability. Only four of the six priority pollutant esters were included in the study. Phthalate esters do biconcentrate in fish. The factors, weighted for relative consumption of various aquatic and marine food groups, are used to calculate ambient water quality criteria for four phthalate esters. The values are included in the discussion of the specific esters.

Studies of toxicity of phthalate esters in freshwater and salt water organisms are scarce. A chronic toxicity test with bis(2-ethylhexyl) phthalate showed that significant reproductive impairment occurred at 0.003 mg/l in the freshwater crustacean, Daphnia magna. In acute toxicity studies, saltwater fish and organisms showed sensitivity differences of up to eight-fold to butyl benzyl, diethyl, and dimethyl phthalates. This suggests that each ester must be evaluated individually for toxic effects.

The behavior of phthalate esters in POTW has not been studied. However, the biochemical oxidation of many of the organic priority pollutants has been investigated in laboratory-scale studies at concentrations higher than would normally be expected in municipal wastewater. Three of the phthalate esters were studied. Bis(2-ethylhexyl) phthalate was found to be degraded slightly or not at all and its removal by biological treatment in a POTW is expected to be slight or zero. Di-n-butyl phthalate and diethyl phthalate were degraded to a moderate degree and their removal by biological treatment in a POTW is expected to occur to a moderate degree. Using these data and other observations relating molecular structure to ease of biochemical degradation of other organic pollutants, the conclusion was reached that butyl benzyl phthalate and dimethyl phthalate would be removed in a POTW to a moderate degree by biological treatment. On the same basis, it was concluded that di-n-octyl phthalate would be removed to a slight degree or not at all.

No information was found on possible interference with POTW operation or the possible effects on sludge by the phthalate esters. The water insoluble phthalate esters - butyl benzyl and di-n-octyl phthalate - would tend to remain in sludge, whereas the other four priority pollutant phthalate esters with water solubilities ranging from 50 mg/l to 4.5 mg/l would probably pass through into the POTW effluent.

Bis (2-ethylhexyl) phthalate(66). Little information is available about the physical properties of bis(2-ethylhexyl) phthalate. It is a liquid boiling at 387°C at 5mm Hg and is insoluble in water. Its formula is $C_6H_4(COOC_8H_{17})_2$. This priority pollutant constitutes about one third of the phthalate ester production in the U.S. It is commonly referred to as dioctyl phthalate, or DOP, in the plastics industry where it is the most extensively used compound for the plasticization of polyvinyl chloride (PVC). Bis(2-ethylhexyl) phthalate has been approved by the FDA for use in plastics in contact with food. Therefore, it may be found in wastewaters coming in contact with discarded plastic food wrappers as well as the PVC films and shapes normally found in industrial plants. This priority pollutant is also a commonly used organic diffusion pump oil where its low vapor pressure is an advantage.

For the protection of human health from the toxic properties of bis(2-ethylhexyl) phthalate ingested through water and through contaminated aquatic organisms, the ambient water quality criterion is determined to be 15 mg/l.

Although the behavior of bis(2-ethylhexyl) phthalate in POTW has not been studied, biochemical oxidation of this priority pollutant has been studied on a laboratory scale at concentrations higher than would normally be expected in municipal wastewater. In fresh water with a non-acclimated seed culture, no biochemical oxidation was observed after 5, 10, and 20 days; with an acclimated seed culture, however, biological oxidation of 13, 0, 6, and 23 percent of theoretical occurred after 5, 10, 15 and 20 days, respectively. Bis(2-ethylhexyl) phthalate concentrations were 3 to 10 mg/l. Little or no removal of bis(2-ethylhexyl) phthalate by biological treatment in POTW is expected.

Butyl benzyl phthalate(67). No information was found on the physical properties of this compound.

Butyl benzyl phthalate is used as a plasticizer for PVC. Two special applications differentiate it from other phthalate esters. It is approved by the U.S. FDA for food contact in wrappers and containers; and it is the industry standard for plasticization of vinyl flooring because it provides stain resistance.

No ambient water quality criterion is proposed for butyl benzyl phthalate.

Butyl benzyl phthalate removal in POTW by biological treatment in a POTW is expected to occur to a moderate degree.

Di-n-butyl phthalate (68). Di-n-butyl phthalate (DBP) is a colorless, oily liquid, boiling at 340°C. Its water solubility at room temperature is reported to be 0.4 g/l and 4.5g/l in two different chemistry handbooks. The formula for DBP, $C_6H_4(COOC_4H_9)_2$ is the same as for its isomer, di-isobutyl phthalate. DBP production is one to two percent of total U.S. phthalate ester production.

DBP is used to a limited extent as a plasticizer for polyvinyl chloride (PVC). It is not approved for contact with food. It is used in liquid lipsticks and as a diluent for polysulfide dental impression materials. DBP is used as a plasticizer for nitrocellulose in making gun powder, and as a fuel in solid propellants for rockets. Further uses are insecticides, safety glass manufacture, textile lubricating agents, printing inks, adhesives, paper coatings and resin solvents.

For protection of human health from the toxic properties of dibutyl phthalate ingested through water and through contaminated aquatic organisms, the ambient water quality criterion is determined to be 34 mg/l.

Although the behavior of di-n-butyl phthalate in POTW has not been studied, biochemical oxidation of this priority pollutant has been studied on a laboratory scale at concentrations higher than would normally be expected in municipal wastewater. Biochemical oxidation of 35, 43, and 45 percent of theoretical oxidation were obtained after 5, 10, and 20 days, respectively, using sewage microorganisms as an unacclimated seed culture.

Biological treatment in POTW is expected to remove di-n-butyl phthalate to a moderate degree.

Di-n-octyl phthalate(69). Di-n-octyl phthalate is not to be confused with the isomeric bis(2-ethylhexyl) phthalate which is commonly referred to in the plastics industry as DOP. Di-n-octyl phthalate is a liquid which boils at 220°C at 5 mm Hg. It is insoluble in water. Its molecular formula is $C_6H_4(COOC_8H_{17})_2$. Its production constitutes about one percent of all phthalate ester production in the U.S.

Industrially, di-n-octyl phthalate is used to plasticize polyvinyl chloride (PVC) resins.

No ambient water quality criterion is proposed for di-n-octyl phthalate.

Biological treatment in POTW is expected to remove little or no di-n-octyl phthalate.

Diethyl phthalate (70). Diethyl phthalate, or DEP, is a colorless liquid which boils at 296°C and is insoluble in water. Its molecular formula is $C_6H_4(COOC_2H_5)_2$. Production of diethyl phthalate constitutes about 1.5 percent of phthalate ester production in the U.S.

Diethyl phthalate is approved for use in plastic food containers by the U.S. FDA. In addition to its use as a polyvinyl chloride (PVC) plasticizer, DEP is used to plasticize cellulose nitrate for gun powder, to dilute polysulfide dental impression materials, and as an accelerator for dyeing triacetate fibers. An additional use which contributes to its wide distribution in the environment is as an approved special denaturant for ethyl alcohol. The alcohol-containing products for which DEP is an approved denaturant include a wide range of personal care items such as bath preparations, bay rum, colognes, hair preparations, face and hand creams, perfumes and toilet soaps. Additionally, this denaturant is approved for use in biocides, cleaning solutions, disinfectants, insecticides, fungicides, and room deodorants which have ethyl alcohol as part of the formulation. It is expected, therefore, that people and buildings would have some surface loading of this priority pollutant which would find its way into raw wastewaters.

For the protection of human health from the toxic properties of diethyl phthalate ingested through water and through contaminated aquatic organisms, the ambient water quality criterion is determined to be 350 mg/l.

Although the behavior of diethylphthalate in POTW has not been studied, biochemical oxidation of this priority pollutant has been studied on a laboratory scale at concentrations higher than would normally be expected in municipal wastewater. Biochemical oxidation of 79, 84, and 89 percent of theoretical oxidation was observed after 5, 5, and 20 days, respectively. Biological treatment in POTW is expected to lead to a moderate degree of removal of diethyl phthalate.

Dimethyl phthalate (71). Dimethyl phthalate (DMP) has the lowest molecular weight of the phthalate esters - M.W. = 194 compared to M.W. of 391 for bis(2-ethylhexyl)phthalate. DMP has a boiling point of 282°C. It is a colorless liquid, soluble in water to the extent of 5 mg/l. Its molecular formula is $C_6H_4(COOCH_3)_2$.

Dimethyl phthalate production in the U.S. is just under one percent of total phthalate ester production. DMP is used to some extent as a plasticizer in cellulosics. However, its principle specific use is for dispersion of polyvinylidene fluoride (PVDF). PVDF is resistant to most chemicals and finds use as electrical insulation, chemical process equipment (particularly pipe), and as a base for long-life finishes for exterior metal siding. Coil coating techniques are used to apply PVDF dispersions to aluminum or galvanized steel siding.

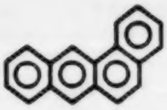
For the protection of human health from the toxic properties of dimethyl phthalate ingested through water and through contaminated aquatic organisms, the ambient water quality criterion is determined to be 160 mg/l.

Biological treatment in POTW's is expected to provide a moderate degree of removal of dimethyl phthalate.

Polynuclear Aromatic Hydrocarbons(72-84). The polynuclear aromatic hydrocarbons (PAH) selected as priority pollutants are a group of 13 compounds consisting of substituted and unsubstituted polycyclic aromatic rings. The general class of PAH includes hetrocyclics, but none of those were selected as priority pollutants. PAH are formed as the result of incomplete combustion when organic compounds are burned with insufficient oxygen. PAH are found in coke oven emissions, vehicular emissions, and volatile products of oil and gas burning. The compounds chosen as priority pollutants are listed with their structural formula and melting point (m.p.). All are insoluble in water.

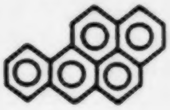
72 Benzo(a)anthracene (1,2-benzanthracene)

m.p. 162°C



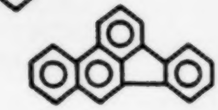
73 Benzo(a)pyrene (3,4-benzopyrene)

m.p. 176°C



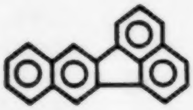
74 3,4-Benzofluoranthene

m.p. 168°C



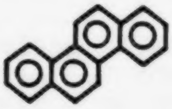
75 Benzo(k)fluoranthene (11,12-benzofluoranthene)

m.p. 217°C



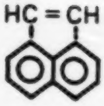
76 Chrysene (1,2-benzphenanthrene)

m.p. 255°C



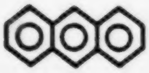
77 Acenaphthylene
HC=CH

m.p. 92°C



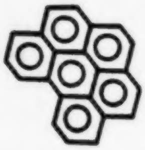
78 Anthracene

m.p. 216°C



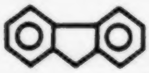
79 Benzo(ghi)perylene (1,12-benzoperylene)

m.p. not reported



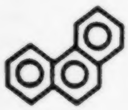
80 Fluorene (alpha-diphenylenemethane)

m.p. 116°C



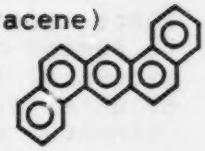
81 Phenanthrene

m.p. 101°C



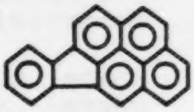
82 Dibenzo(a,h)anthracene (1,2,4,5,6-dibenzanthracene)

m.p. 269°C



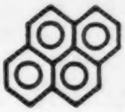
83 Indeno(1,2,3-cd)pyrene (2,3-o-phenylene pyrene)

m.p. not available



84 Pyrene

m.p. 156°C



Some of these priority pollutants have commercial or industrial uses. Benzo(a)anthracene, benzo(a)pyrene, chrysene, anthracene, dibenzo(a,h)anthracene, and pyrene are all used as antioxidants. Chrysene, acenaphthylene, anthracene, fluorene, phenanthrene, and pyrene are all used for synthesis of dyestuffs or other organic chemicals. 3,4-Benzofluoranthrene, benzo(k)fluoranthene, benzo(ghi)perylene, and indeno (1,2,3-cd)pyrene have no known industrial uses, according to the results of a recent literature search.

Several of the PAH priority pollutants are found in smoked meats, in smoke flavoring mixtures, in vegetable oils, and in coffee. They are found in soils and sediments in river beds. Consequently, they are also found in many drinking water supplies. The wide distribution of these pollutants in complex mixtures with the many other PAHs which have not been designated as priority pollutants results in exposures by humans that cannot be associated with specific individual compounds.

The screening and verification analysis procedures used for the organic priority pollutants are based on gas chromatography (GC). Three pairs of the PAH have identical elution times on the column specified in the protocol, which means that the parameters of the pair are not differentiated. For these three pairs [anthracene (78) - phenanthrene (81); 3,4-benzofluoranthene (74) - benzo(k)fluoranthene (75); and benzo(a)anthracene (72) - chrysene (76)] results are obtained and reported as "either-or." Either both are present in the combined concentration reported, or one is present in the concentration reported. When detections below reportable limits are recorded no further analysis is required. For samples where the concentrations of coeluting pairs have a significant value, additional analyses are conducted, using different procedures that resolve the particular pair.

There are no studies to document the possible carcinogenic risks to humans by direct ingestion. Air pollution studies indicate an excess of lung cancer mortality among workers exposed to large amounts of PAH containing materials such as coal gas, tars, and coke-oven emissions. However, no definite proof exists that the PAH present in these materials are responsible for the cancers observed.

Animal studies have demonstrated the toxicity of PAH by oral and dermal administration. The carcinogenicity of PAH has been traced to formation of PAH metabolites which in turn lead to tumor formation. Because the levels of PAH which induce cancer are very low, little work has been done on other health hazards resulting from exposure. It has been established in animal studies that tissue damage and systemic toxicity can result from exposure to non-carcinogenic PAH compounds.

Because there were no studies available regarding chronic oral exposures to PAH mixtures, proposed water quality criteria were derived using data on exposure to a single compound. Two studies were selected, one involving benzo(a)pyrene ingestion and one involving dibenzo(a,h)anthracene ingestion. Both are known animal carcinogens.

For the maximum protection of human health from the potential carcinogenic effects of exposure to polynuclear aromatic hydrocarbons (PAH) through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of PAH estimated to result in additional lifetime cancer risks of 10^{-5}, 10^{-6}, or 10^{-7} are 0.000028 mg/l, 0.0000028 mg/l, and 0.00000028 mg/l, respectively.

No standard toxicity tests have been reported for freshwater or saltwater organisms and any of the 13 PAH discussed here.

The behavior of PAH in POTW has received only a limited amount of study. Reports have indicated that up to 90 percent of PAH entering a POTW will be retained in the sludge generated by conventional sewage treatment processes. Some of the PAH can inhibit bacterial growth when they are present at concentrations as low as 0.018 mg/l. Biological treatment in activated sludge units has been shown to reduce the concentration of phenanthrene and anthracene to some extent. However, a study of biochemcial oxidation of fluorene on a laboratory scale showed no degradation after 5, 10, and 20 days. On the basis of that study and studies of other organic priority pollutants, some general observations were made relating molecular structure to ease of degradation. Those observations lead to the conclusion that the 13 PAH selected to represent that group as priority pollutants will be removed only slightly or not at all by biological treatment methods in POTW. Based on their water insolubility and tendency to attach to sediment particles very little pass through of PAH to POTW effluent is expected.

In an Agency study, Fate of Priority Pollutants in Publicly Owned Treatment Works, the pollutant concentrations in the influent, effluent and (EPA-440/1-80-301, October 1980) sludge of 20 POTW's were measured. The results show that indeed the PAH's are concentrated in the sludges and that little or no PAH's are discharged in the effluent of POTW's. The differences in average concentrations from influent to effluent range from 50 to 100% removal with all but one PAH above 80% removal. The data indicate that all or nearly all of the PAH's are concentrated in the sludge.

No data are available at this time to support any conclusions about contamination of land by PAH on which sewage sludge containing PAH is spread.

Toluene(86). Toluene is a clear, colorless liquid with a benzene like odor. It is a naturally occuring compound derived primarily from petroleum or petrochemical processes. Some toluene is obtained from the manufacture of metallurgical coke. Toluene is also referred to as toluol, methylbenzene, methacide, and phenylmethane. It is an aromatic hydrocarbon with the formula $C_6H_5CH_3$. It boils at 111°C and has a vapor pressure of 30 mm Hg at room temperature. The water solubility of toluene is 535 mg/l, and it is miscible with a variety of organic solvents. Annual production of toluene in the U.S. is greater than 2 million metric tons. Approximately two-thirds of the toluene is converted to benzene; the remaining 30 percent is divided approximately equally into chemical manufacture and use as a paint solvent and aviation gasoline additive. An estimated 5,000 metric tons is discharged to the environment annually as a constituent in wastewater.

Most data on the effects of toluene in human and other mammals have been based on inhalation exposure or dermal contact studies. There appear to be no reports of oral administration of toluene to human subjects. A long term toxicity study on female rats revealed no adverse effects on growth, mortality, appearance and behavior, organ to body weight ratios, blood-urea nitrogen levels, bone marrow counts, peripheral blood counts, or morphology of major organs. The effects of inhaled toluene on the central nervous system, both at high and low concentrations, have been studied in humans and animals. However, ingested toluene is expected to be handled differently by the body because it is absorbed more slowly and must first pass through the liver before reaching the nervous system. Toluene is extensively and rapidly metabolized in the liver. One of the principal metabolic products of toluene is benzoic acid, which itself seems to have little potential to produce tissue injury.

Toluene does not appear to be teratogenic in laboratory animals or man. Nor is there any conclusive evidence that toluene is mutagenic. Toluene has not been demonstrated to be positive in any *in vitro* mutagenicity or carcinogenicity bioassay system, nor to be carcinogenic in animals or man.

Toluene has been found in fish caught in harbor waters in the vicinity of petroleum and petrochemical plants. Bioconcentration studies have not been conducted, but bioconcentration factors have been calculated on the basis of the octanol-water partition coefficient.

For the protection of human health from the toxic properties of toluene ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 14.3 mg/l.

Acute toxicity tests have been conducted with toluene and a variety of freshwater fish and *Daphnia magna*. The latter appears to be significantly more resistant than fish. No test results have been reported for the chronic effects of toluene on freshwater fish or invertebrate species.

No detailed study of toluene behavior in POTW is available. However, the biochemical oxidation of many of the priority pollutants has been investigated in laboratory scale studies at concentrations greater than those expected to be contained by most municipal wastewaters. At toluene concentrations ranging from 3 to 250 mg/l biochemical oxidation proceeded to fifty percent of theoretical oxidation or greater. The time period varied from a few hours to 20 days, depending on whether or not the seed culture was acclimated. Phenol adapted acclimated seed cultures gave the most rapid and extensive biochemical oxidation. The conclusion reached by study of the limited data is that biological treatment produces moderate removal of toluene in POTW. The volatility and relatively low water solubility of toluene lead to the expectation that aeration processes will remove significant quantities of toluene from the POTW.

Trichloroethylene(87). Trichloroethylene (1,1,2-trichloroethylene or TCE) is a clear colorless liquid which boils at 87°C. It has a vapor pressure of 77 mm Hg at room temperature and is slightly soluble in water (1 gm/l). U.S. production is greater than 0.25 million metric tons annually. It is produced from tetrachloroethane by treatment with lime in the presence of water.

TCE is used for vapor phase degreasing of metal parts, cleaning and drying electronic components, as a solvent for paints, as a refrigerant, for extraction of oils, fats, and waxes, and for dry cleaning. Its widespread use and relatively high volatility result in detectable levels in many parts of the environment.

Data on the effects produced by ingested TCE are limited. Most studies have been directed at inhalation exposure. Nervous system disorders and liver damage are frequent results of inhalation exposure. In the short term exposures, TCE acts as a central nervous system depressant - it was used as an anesthetic before its other long term effects were defined.

TCE has been shown to induce transformation in a highly sensitive in vitro Fischer rat embryo cell system (F1706) that is used for identifying carcinogens. Severe and persistant toxicity to the liver was recently demonstrated when TCE was shown to produce carcinoma of the liver in mouse strain B6C3F1. One systematic study of TCE exposure and the incidence of human cancer was based on 518 men exposed to TCE. The authors of that study concluded that although the cancer risk to man cannot be ruled out, exposure to low levels of TCE probably does not present a very serious and general cancer hazard.

TCE is bioconcentrated in aquatic species, making the consumption of such species by humans a significant source of TCE. For the protection of human health from the potential carcinogenic effects of exposure to trichloroethylene through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of trichloroethylene estimated to result in additional lifetime cancer risk of 10^{-7}, 10^{-6}, and 10^{-5} are 2.7×10^{-4} mg/l, 2.7×10^{-3} mg/l, and 2.7×10^{-2} mg/l, respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 0.807 mg/l to keep the additional lifetime cancer risk below 10^{-5}.

Only a very limited amount of data on the effects of TCE on freshwater aquatic life are available. One species of fish (fathead minnows) showed a loss of equilibrium at concentrations below those resulting in lethal effects. The limited data for aquatic life show that adverse effects occur at concentrations higher than those cited for human health risks.

In laboratory scale studies of organic priority pollutants, TCE was subjected to biochemical oxidation conditions. After 5, 10, and 20 days no biochemical oxidation occurred. On the basis of this study and general observations relating molecular structure to ease of degradation, the conclusion is reached that TCE would undergo little or no biochemical oxidation by biological treatment in a POTW. The volatility and relatively low water solubility of TCE is expected to result in volatilization of some of the TCE in aeration steps in a POTW.

In an Agency study, Fate of Priority Pollutants in Publicly Owned Treatment Works, (EPA 440/1-30-301), the pollutant concentrations in the influent, effluent, and sludge of 20 POTW's were measured. No conclusions were made; however, trichloroethylene appeared in 95% of the influent stream samples but only in 54% of the effluent stream samples. This indicates that trichloroethylene either is concentrated in the sludge or escapes to the atmosphere. Concentrations in 50% of the sludge samples indicate that much of the trichloroethylene is concentrated there.

Cadmium(118). Cadmium is a relatively rare metallic element that is seldom found in sufficient quantities in a pure state to warrant mining or extraction from the earth's surface. It is found in trace amounts of about 1 ppm throughout the earth's crust. Cadmium is, however, a valuable by-product of zinc production.

Cadmium is used primarily as an electroplated metal, and is found as an impurity in the secondary refining of zinc, lead, and copper. Cadmium appears at a significant level in raw wastewaters from only one of the three subcategories of coil coating - galvanized. The presence of cadmium in the wastewater is attributed to its presence as an impurity in the zinc used to produce galvanized coil stock. Some of the zinc is removed by the cleaning and conversion coating steps.

Cadmium is an extremely dangerous cumulative toxicant, causing progressive chronic poisoning in mammals, fish, and probably other organisms. The metal is not excreted.

Toxic effects of cadmium on man have been reported from throughout the world. Cadmium may be a factor in the development of such human pathological conditions as kidney disease, testicular tumors, hypertension, arteriosclerosis, growth inhibition, chronic disease of old age, and cancer. Cadmium is normally ingested by humans through food and water as well as by breathing air contaminated by cadmium dust. Cadmium is cumulative in the liver, kidney, pancreas, and thyroid of humans and other animals. A severe bone and kidney syndrome known as itai-itai disease has been documented in Japan as caused by cadmium ingestion via drinking water and contaminated irrigation water. Ingestion of as little as 0.6 mg/day has produced the disease. Cadmium acts synergistically with other metals. Copper and zinc substantially increase its toxicity.

Cadmium is concentrated by marine organisms, particularly molluscs, which accumulate cadmium in calcareous tissues and in the viscera. A concentration factor of 1000 for cadmium in fish muscle has been reported, as have concentration factors of 3000 in marine plants and up to 29,600 in certain marine animals. The eggs and larvae of fish are apparently more sensitive than adult fish to poisoning by cadmium, and crustaceans appear to be more sensitive than fish eggs and larvae.

For the protection of human health from the toxic properties of cadmium ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 0.010 mg/l.

Cadmium is not destroyed when it is introduced into a POTW, and will either pass through to the POTW effluent or be incorporated into the POTW sludge. In addition, it can interfere with the POTW treatment process.

In a study of 189 POTW, 75 percent of the primary plants, 57 percent of the trickling filter plants, 66 percent of the activated sludge plants and 62 percent of the biological plants allowed over 90 percent of the influent cadmium to pass through to the POTW effluent. Only 2 of the 189 POTW allowed less than 20 percent pass-through, and none less than 10 percent pass-through. POTW effluent concentrations ranged from 0.001 to 1.97 mg/l (mean 0.028 mg/l, standard deviation 0.167 mg/l).

Cadmium not passed through the POTW will be retained in the sludge, where it is likely to build up in concentration. Cadmium contamination of sewage sludge limits its use on land since it increases the level of cadmium in the soil. Data show that cadmium can be incorporated into crops, including vegetables and grains, from contaminated soils. Since the crops themselves show no adverse effects from soils with levels up to 100 mg/kg cadmium, these contaminated crops could have a significant impact on human health. Two Federal agencies have already recognized the potential adverse human health effects posed by the use of sludge on cropland. The FDA recommends that sludge containing over 30 mg/kg of cadmium should not be used on agricultural land. Sewage sludge contains 3 to 300 mg/kg (dry basis) of cadmium mean = 10 mg/kg; median = 16 mg/kg. The USDA also recommends placing limits on the total cadmium from sludge that may be applied to land.

Chromium(119). Chromium is an elemental metal usually found as a chromite ($FeO \bullet Cr_2O_3$). The metal is normally produced by reducing the oxide with aluminum. A significant proportion of the chromium used is in the form of compounds such as sodium dichromate (Na_2CrO_4), and chromic acid (CrO_3) - both are hexavalent chromium compounds.

Chromium and its compounds are used extensively in the coil coating industry. As the metal, it is found as an alloying component of many steels.

The two chromium forms most frequently found in industry wastewaters are hexavalent and trivalent chromium. Hexavalaent chromium is the form used for metal treatments. Some of it is reduced to trivalent chromium as part of the process reaction. The raw wastewater containing both valence states is usually treated first to reduce remaining hexavalent to trivalent chromium, and second to precipitate the trivalent form as the hydroxide. The hexavalent form is not removed by lime treatment.

Chromium, in its various valence states, is hazardous to man. It can produce lung tumors when inhaled, and induces skin sensitizations. Large doses of chromates have corrosive effects on the intestinal tract and can cause inflammation of the kidneys. Hexavalent chromium is a known human carcinogen. Levels of chromate ions that show no effect in man appear to be so low as to prohibit determination, to date.

The toxicity of chromium salts to fish and other aquatic life varies widely with the species, temperature, pH, valence of the chromium, and synergistic or antagonistic effects, especially the effect of water hardness. Studies have shown that trivalent chromium is more toxic to fish of some types than is hexavalent chromium. Hexavalent chromium retards growth of one fish species at 0.0002 mg/l. Fish food organisms and other lower forms of aquatic life are extremely sensitive to chromium. Therefore, both hexavalent and trivalent chromium must be considered harmful to particular fish or organisms.

For the protection of human health from the toxic properties of chromium (except hexavalent chromium) ingested through water and contaminated aquatic organisms, the recommended water qualtiy criterion is 170 mg/l.

For the protection of human health from the toxic effects of exposure to hexavalent chromium through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero.

Chromium is not destroyed when treated by POTW (although the oxidation state may change), and will either pass through to the POTW effluent or be incorporated into the POTW sludge. Both oxidation states can inhibit POTW treatment and can also limit the usefuleness of municipal sludge.

EPA has observed influent concentrations of chromium to POTW facilities to range from 0.005 to 14.0 mg/l, with a median concentration of 0.1 mg/l. The efficiencies for removal of chromium by the activated sludge process can vary greatly, depending on chromium concentration in the influent, and other operating conditions at the POTW. Chelation of chromium by organic matter and dissolution due to the presence of carbonates can cause deviations from the predicted behavior in treatment systems.

The systematic presence of chromium compounds will halt nitrification in a POTW for short periods, and most of the chromium will be retained in the sludge solids. Hexavalent chromium has been reported to severely affect the nitrification process, but trivalent chromium has little or no toxicity to activated sludge, except at high concentrations. The presence of iron, copper, and low pH will increase the toxicity of chromium in a POTW by releasing the chromium into solution to be ingested by microorganisms in the POTW.

The amount of chromium which passes through to the POTW effluent depends on the type of treatment processes used by the POTW. In a study of 240 POTW's, 56 percent of the primary plants allowed more than 80 percent pass through to POTW effluent. More advanced treatment results in less pass-through. POTW effluent concentrations ranged from 0.003 to 3.2 mg/l total chromium (mean = 0.197, standard deviation = 0.48), and from 0.002 to 0.1 mg/l hexavalent chromium (mean = 0.017, standard deviation = 0.020).

Chromium not passed through the POTW will be retained in the sludge, where it is likely to build up in concentration. Sludge concentrations of total chromium of over 20,000 mg/kg (dry basis) have been observed. Disposal of sludges containing very high concentrations of trivalent chromium can potentially cause problems in uncontrollable landfills. Incineration, or similar destructive oxidation processes can produce hexavalent chromium from lower valance states. Hexavalent chromium is potentially more toxic than trivalent chromium. In cases where high rates of chrome sludge application on land are used, distinct growth inhibition and plant tissue uptake have been noted.

Pretreatment of discharges substantially reduces the concentration of chromium in sludge. In Buffalo, New York, pretreatment of electroplating waste resulted in a decrease in chromium concentrations in POTW sludge from 2,510 to 1,040 mg/kg. A similar reduction occurred in a Grand Rapids, Michigan, POTW where the chromium concentration in sludge decreased from 11,000 to 2,700 mg/kg when pretreatment was required.

Copper(120). Copper is a metallic element that sometimes is found free, as the native metal, and is also found in minerals such as cuprite (Cu_2O), malechite [$CuCO_3 \bullet Cu(OH)_2$], azurite [$2CuCO_3 \bullet Cu(OH)_2$], chalcopyrite ($CuFeS_2$), and bornite (Cu_5FeS_4). Copper is obtained from these ores by smelting, leaching, and electrolysis. It is used in the plating, electrical, plumbing, and heating equipment industries, as well as in insecticides and fungicides. In the coil coating industry copper can be attributed to various contaminant sources.

Traces of copper are found in all forms of plant and animal life, and the metal is an essential trace element for nutrition. Copper is not considered to be a cumulative systemic poison for humans because it is readily excreted by the body, but it can cause symptoms of gastroenteritis, with nausea and intestinal irritations, at relatively low dosages. The limiting factor in domestic water supplies is taste. To prevent this adverse organoleptic effect of copper in water, a criterion of 1 mg/l has been established.

The toxicity of copper to aquatic organisms varies significantly, not only with the species, but also with the physical and chemical characteristics of the water, including temperature, hardness, turbidity, and carbon dioxide content. In hard water, the toxicity of copper salts may be reduced by the precipitation of copper carbonate or other insoluble compounds. The sulfates of copper and zinc, and of copper and calcium are synergistic in their toxic effect on fish.

Relatively high concentrations of copper may be tolerated by adult fish for short periods of time; the critical effect of copper appears to be its higher toxicity to young or juvenile fish. Concentrations of 0.02 to 0.031 mg/l have proved fatal to some common fish species. In general the salmonoids are very sensitive and the sunfishes are less sensitive to copper.

The recommended criterion to protect saltwater aquatic life is 0.004 mg/l as a 24-hour average, and 0.023 mg/l maximum concentration.

Copper salts cause undesirable color reactions in the food industry and cause pitting when deposited on some other metals such as aluminum and galvanized steel.

Irrigation water containing more than minute quantities of copper can be detrimental to certain crops. Copper appears in all soils, and its concentration ranges from 10 to 80 ppm. In soils, copper occurs in association with hydrous oxides of manganese and iron, and also as soluble and insoluble complexes with organic matter. Copper is essential to the life of plants, and the normal range of concentration in plant tissue is from 5 to 20 ppm. Copper concentrations in plants normally do not build up to high levels when toxicity occurs. For example, the concentrations of copper in snapbean leaves and pods was less than 50 and 20 mg/kg, respectively, under conditions of severe copper toxicity. Even under conditions of copper toxicity, most of the excess copper accumulates in the roots; very little is moved to the aerial part of the plant.

Copper is not destroyed when treated by a POTW, and will either pass through to the POTW effluent or be retained in the POTW sludge. It can interfere with the POTW treatment processes and can limit the usefulness of municipal sludge.

The influent concentration of copper to POTW facilities has been observed by the EPA to range from 0.01 to 1.97 mg/l, with a median concentration of 0.12 mg/l. The copper that is removed from the influent stream of a POTW is adsorbed on the sludge or appears in the sludge as the hydroxide of the metal. Bench scale pilot studies have shown that from about 25 percent to 75 percent of the copper passing through the activated sludge process remains in solution in the final effluent. Four-hour slug dosages of copper sulfate in concentrations exceeding 50 mg/l were reported to have severe effects on the removal efficiency of an unacclimated system, with the system returning to normal in about 100 hours. Slug dosages of copper in the form of copper cyanide were observed to have much more severe effects on the activated sludge system, but the total system returned to normal in 24 hours.

In a recent study of 268 POTW, the median pass-through was over 80 percent for primary plants and 40 to 50 percent for trickling filter, activated sludge, and biological treatment plants. POTW effluent concentrations of copper ranged from 0.003 to 1.8 mg/l (mean 0.126, standard deviation 0.242).

Copper which does not pass through the POTW will be retained in the sludge where it will build up in concentration. The presence of excessive levels of copper in sludge may limit its use on cropland. Sewage sludge contains up to 16,000 mg/kg of copper, with 730 mg/kg as the mean value. These concentrations are significantly greater than those normally found in soil, which usually range from 18 to 80 mg/kg. Experimental data indicate that when dried sludge is spread over tillable land, the copper tends to remain in place down to the depth of tillage, except for copper which is taken up by plants grown in the soil. Recent investigation has shown that the extractable copper content of sludge-treated soil decreased with time, which suggests a reversion of copper to less soluble forms was occurring.

Cyanide(121). Cyanide compounds are widely used in the coil coating industry, primarily for accelerating action of chromating solutions.

Cyanides are among the most toxic of pollutants commonly observed in industrial wastewaters. Introduction of cyanide into industrial processes is usually by dissolution of potassium cyanide (KCN) or sodium cyanide (NaCN) in process waters; however, the hydrogen cyanide (HCN) formed when the above salts are dissolved in water is probably the most acutely lethal compound.

The relationship of pH to hydrogen cyanide formation is very important. As pH decreases below 7, more than 99 percent of the cyanide is present as HCN and less than 1 percent as cyanide ions. Thus, at neutral pH, that of most living organisms, the more toxic form of cyanide prevails.

Cyanide ions combine with numerous heavy metal ions to form complexes. The complexes are in equilibrium with HCN. Thus, the stability of the metal-cyanide complex and the pH determine the concentration of HCN. Stability of the metal-cyanide anion complexes is extremely variable. Those formed with zinc, copper, and cadmium are not stable - they rapidly dissociate, with production of HCN, in near neutral or acid waters. Some of the complexes are extremely stable. Cobaltocyanide is very resistant to acid distillation in the laboratory. Iron cyanide complexes are also stable, but undergo photodecomposition to give HCN upon exposure to sunlight. Synergistic effects have been demonstrated for the metal cyanide complexes making zinc, copper, and cadmium cyanides more toxic than an equal concentration of sodium cyanide.

The toxic mechanism of cyanide is essentially an inhibition of oxygen metabolism, i.e., rendering the tissues incapable of exchanging oxygen. The cyanogen compounds are true noncumulative protoplasmic poisons. They arrest the activity of all forms of animal life. Cyanide shows a very specific type of toxic action. It inhibits the cytochrome oxidase system. This system is the one which facilitates electron transfer from reduced metabolites to molecular oxygen. The human body can convert cyanide to a non-toxic thiocyanate and eliminate it. However, if the quantity of cyanide ingested is too great at one time, the inhibition of oxygen utilization proves fatal before the detoxifying reaction reduces the cyanide concentration to a safe level.

Cyanides are more toxic to fish than to lower forms of aquatic organisms such as midge larvae, crustaceans, and mussels. Toxicity to fish is a function of chemical form and concentration, and is influenced by the rate of metabolism (temperature), the level of dissolved oxygen, and pH. In laboratory studies free cyanide concentrations ranging from 0.05 to 0.15 mg/l have been proven to be fatal to sensitive fish species including trout, bluegill, and fathead minnows. Levels above 0.2 mg/l are rapidly fatal to most fish species. Long term sublethal concentrations of cyanide as low as 0.01 mg/l have been shown to affect the ability of fish to function normally, e.g., reproduce, grow, and swim.

For the protection of human health from the toxic properties of cyanide ingested through water and through contaminated aquatic organisms, the ambient water quality criterion is determined to be 0.200 mg/l.

Persistence of cyanide in water is highly variable and depends upon the chemical form of cyanide in the water, the concentration of cyanide, and the nature of other constituents. Cyanide may be destroyed by strong oxidizing agents such as permanganate and chlorine. Chlorine is commonly used to oxidize strong cyanide solutions. Carbon dioxide and nitrogen are the products of complete oxidation. But if the reaction is not complete, the very toxic compound; cyanogen chloride may remain in the treatment system and subsequently be released to the environment. Partial chlorination may occur as part of a POTW treatment, or during the disinfection treatment of surface water for drinking water preparation.

Cyanides can interfere with treatment processes in POTW, or pass through to ambient waters. At low concentrations and with acclimated microflora, cyanide may be decomposed by microorganisms in anaerobic and aerobic environments or waste treatment systems. However, data indicate that much of the cyanide introduced passes through to the POTW effluent. The mean pass-through of 14 biological plants was 71 percent. In a recent study of 41 POTW, the effluent concentrations ranged from 0.002 to 100 mg/l (mean = 2.518, standard deviation = 15.6). Cyanide also enhances the toxicity of metals commonly found in POTW effluents, including the priority pollutants cadmium, zinc, and copper.

Data for Grand Rapids, Michigan, showed a significant decline in cyanide concentrations downstream from the POTW after pretreatment regulations were put in force. Concentrations fell from 0.66 mg/l before, to 0.01 mg/l after pretreatment was required.

Lead (122). Lead is a soft, malleable ductible, bluish-gray, metallic element, usually obtained from the mineral galena (lead sulfide, PbS), anglesite (lead sulfate, $PbSO_4$), or cerussite (lead carbonate, $PbCO_3$). Because it is usually associated with the minerals zinc, silver, copper, gold, cadmium, antimony, and arsenic, special purification methods are frequently used before and after extraction of the metal from the ore concentrate by smelting.

Lead is widely used for its corrosion resistance, sound and vibration absorption, low melting point (solders), and relatively high imperviousness to various forms of radiation. Small amounts of copper, antimony and other metals can be alloyed with lead to achieve greater hardness, stiffness, or corrosion resistance than is afforded by the pure metal. Lead compounds are used in glazes and paints. About one third of U.S. lead consumption goes into storage batteries. About half of U.S. lead consumption is from secondary lead recovery. U.S. consumption of lead is in the range of one million tons annually.

Lead ingested by humans produces a variety of toxic effects including impaired reproductive ability, disturbances in blood chemistry, neurological disorders, kidney damage, and adverse cardiovascular effects. Exposure to lead in the diet results in permanent increase in lead levels in the body. Most of the lead entering the body eventually becomes localized in the bones where it accumulates. Lead is a carcinogen or cocarcinogen in some species of experimental animals. Lead is teratogenic in experimental animals. Mutangenicity data are not available for lead.

For the protection of human health from the toxic properties of lead ingested through water and through contaminated aquatic organisms, the ambient water criterion is 0.050 mg/l.

Lead is not destroyed in POTW, but is passed through to the effluent or retained in the POTW sludge; it can interfere with POTW treatment processes and can limit the usefulness of POTW sludge for application to agricultural croplands. Threshold concentration for inhibition of the activated sludge process is 0.1 mg/l, and for the nitrification process is 0.5 mg/l. In a study of 214 POTW, median pass through values were over 80 percent for primary plants and over 60 percent for trickling filter, activated sludge, and biological process plants. Lead concentration in POTW effluents ranged from 0.003 to 1.8 mg/l (means = 0.106 mg/l, standard deviation = 0.222).

Application of lead-containing sludge to cropland should not lead to uptake by crops under most conditions because normally lead is strongly bound by soil. However, under the unusual conditions of low pH (less than 5.5) and low concentrations of labile phosphorus, lead solubility is increased and plants can accumulate lead.

Nickel(124). Nickel is seldom found in nature as the pure elemental metal. It is a reltively plentiful element and is widely distributed throughout the earth's crust. It occurs in marine organisms and is found in the oceans. The chief commercial ores for nickel are pentlandite [$(Fe,Ni)_9S_8$], and a lateritic ore consisting of hydrated nickel-iron-magnesium silicate.

Nickel has many and varied uses. It is used in alloys and as the pure metal. Nickel salts are used for electroplating baths. The coil coating industry uses nickel compounds as accelerators in certain conversion coating solutions. Nickel is also found as a contaminant in mineral acids. It occurs in significant concentrations in the wastewaters from all three subcategories of coil coating.

The toxicity of nickel to man is thought to be very low, and systemic poisoning of human beings by nickel or nickel salts is almost unknown. In non-human mammals nickel acts to inhibit insulin release, depress growth, and reduce cholesterol. A high incidence of cancer of the lung and nose has been reported in humans engaged in the refining of nickel.

Nickel salts can kill fish at very low concentrations. However, nickel has been found to be less toxic to some fish than copper, zinc, and iron. Nickel is present in coastal and open ocean water at concentrations in the range of 0.0001 to 0.006 mg/l although the most common values are 0.002 - 0.003 mg/l. Marine animals contain up to 0.4 mg/l and marine plants contain up to 3 mg/l. Higher nickel concentrations have been reported to cause reduction in photosynthetic activity of the giant kelp. A low concentration was found to kill oyster eggs.

For the protection of human health based on the toxic properties of nickel ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 0.0134 mg/l.

Nickel is not destroyed when treated in a POTW, but will either pass through to the POTW effluent or be retained in the POTW sludge. It can interfere with POTW treatment processes and can also limit the usefulness of municipal sludge.

Nickel salts have caused inhibition of the biochemical oxidation of sewage in a POTW. In a pilot plant, slug doses of nickel significantly reduced normal treatment efficiencies for a few hours, but the plant acclimated itself somewhat to the slug dosage and appeared to achieve normal treatment efficiencies within 40 hours. It has been reported that the anaerobic digestion process is inhibited only by high concentrations of nickel, while a low concentration of nickel inhibits the nitrification process.

EPA has observed influent concentration of nickel to POTW facilities ranging from 0.01 to 3.19 mg/l, with a median of 0.33 mg/l. In a study of 190 POTW, nickel pass-through was greater than 90 percent for 82 percent of the primary plants. Median pass-through for trickling filter, activated sludge, and biological process plants was greater than 80 percent. POTW effuent concentrations ranged from 0.002 to 40 mg/l (mean = 0.410, standard deviation = 3.279).

Nickel not passed through the POTW will be incorporated into the sludge. In a recent two-year study of eight cities, four of the cities had median nickel concentrations of over 350 mg/kg, and two were over 1,000 mg/kg. The maximum nickel concentration observed was 4,010 mg/kg.

Nickel is found in nearly all soils, plants, and waters. Nickel has no known essential function in plants. In soils, nickel typically is found in the range from 10 to 100 mg/kg. Various environmental exposures to nickel appear to correlate with increased incidence of tumors in man. For example, cancer in the maxillary antrum of snuff users may result from using plant material grown on soil high in nickel.

Nickel toxicity may develop in plants from application of sewage sludge on acid soils. Nickel has reduced yields for a variety of crops, including oats, mustard, turnips, and cabbage. In one study, nickel decreased the yields of oats significantly at 100 mg/kg.

Whether nickel exerts a toxic effect on plants depends on several soil factors, the amount of nickel applied, and the contents of other metals in the sludge. Unlike copper and zinc, which are more available from inorganic sources than from sludge, nickel uptake by plants seems to be promoted by the presence of the organic matter in sludge. Soil treatments such as liming reduce the solubility of nickel. Toxicity of nickel to plants is enhanced in acidic soils.

Zinc(128). Zinc occurs abundantly in the earth's crust, concentrated in ores. It is readily refined into the pure, stable, silvery-white metal. In addition to its use in alloys, zinc is used as a protective coating on steel. It is applied by hot dipping (i.e. dipping the steel in molten zinc) or by electroplating. The resulting galvanized steel is used as one of the basis materials for coil coating. Zinc salts are also used in conversion coatings in the coil coating industry.

Zinc can have an adverse effect on man and animals at high concentrations. Zinc at concentrations in excess of 5 mg/l causes an undesirable taste which persists through conventional treatment. For the prevention of adverse effects due to these organoleptic properties of zinc, 5 mg/l was adopted for the ambient water criterion.

Toxic concentrations of zinc compounds cause adverse changes in the morphology and physiology of fish. Lethal concentrations in the range of 0.1 mg/l have been reported. Acutely toxic concentrations induce cellular breakdown of the gills, and possibly the clogging of the gills with mucous. Chronically toxic concentrations of zinc compounds cause general enfeeblement and widespread histological changes to many organs, but not to gills. Abnormal swimming behavior has been reported at 0.04 mg/l. Growth and maturation are retarded by zinc. It has been observed that the effects of zinc poisoning may not become apparent immediately, so that fish removed from zinc-contaminated water may die as long as 48 hours after removal.

In general, salmonoids are most sensitive to elemental zinc in soft water; the rainbow trout is the most sensitive in hard waters. A complex relationship exists between zinc concentration, dissolved zinc concentration, pH, temperature, and calcium and magnesium concentration. Prediction of harmful effects has been less than reliable and controlled studies have not been extensively documented.

The major concern with zinc compounds in marine waters is not with acute lethal effects, but rather with the long-term sublethal effects of the metallic compounds and complexers. Zinc accumulates in some marine species, and marine animals contain zinc in the range of 6 to 1500 mg/kg. From the point of view of acute lethal effects, invertebrate marine animals seem to be the most sensitive organism tested.

Toxicities of zinc in nutrient solutions have been demonstrated for a number of plants. A variety of fresh water plants tested manifested harmful symptoms at concentrations of 10 mg/l. Zinc sulfate has also been found to be lethal to many plants and it could impair agricultural uses of the water.

Zinc is not destroyed when treated by POTW, but will either pass through to the POTW effluent or be retained in the POTW sludge. It can interfere with treatment processes in the POTW and can also limit the usefuleness of municipal sludge.

In slug doses, and particularly in the presence of copper, dissolved zinc can interfere with or seriously disrupt the operation of POTW biological processes by reducing overall removal efficiencies, largely as a result of the toxicity of the metal to biological organisms. However, zinc solids in the form of hydroxides or sulfides do not appear to interfere with biological treatment processes, on the basis of available data. Such solids accumulate in the sludge.

The influent concentrations of zinc to POTW facilities has been observed by the EPA to range from 0.017 to 3.91 mg/l, with a median concentration of 0.33 mg/l. Primary treatment is not efficient in removing zinc; however, the microbial floc of secondary treatment readily adsorbs zinc.

In a study of 258 POTW, the median pass-through values were 70 to 88 percent for primary plants, 50 to 60 percent for trickling filter and biological process plants, and 30-40 percent for activated process plants. POTW effluent concentrations of zinc ranged from 0.003 to 3.6 mg/l (mean = 0.330, standard deviation = 0.464).

The zinc which does not pass through the POTW is retained in the sludge. The presence of zinc in sludge may limit its use on cropland. Sewage sludge contains from 72 to over 30,000 mg/kg of zinc, with 3,366 mg/kg as the mean value. These concentrations are significantly greater than those normally found in soil, which range from 0 to 195 mg/kg, with 94 mg/kg being a common level. Therefore, application of sewage sludge to soil will generally increase the concentration of zinc in the soil. Zinc can be toxic to plants, depending upon soil pH. Lettuce, tomatoes, turnips, mustard, kale, and beets are especially sensitive to zinc contamination.

Aluminum. Aluminum is a non-conventional pollutant. It is a silvery white metal, very abundant in the earth's crust (8.1%), but never found free in nature. Its principal ore is bauxite. Alumina (Al_2O_3) is extracted from the bauxite and dissolved in molten cryolite. Aluminum is produced by electrolysis of this melt.

Aluminum is light, malleable, ductile, possesses high thermal and electrical conductivity, and is non-magnetic. It can be formed, machined or cast. Aluminum is used in the construction, transportation, and container industries and competes with iron and steel in these markets.

Aluminum had been found to be toxic to freshwater and marine aquatic life. In freshwaters acute toxicity and solubility increases as pH levels increase above pH 7. This relationship also appears to be true as the pH levels decrease below pH 7. Chronic effects of aluminum on aquatic life have also been documented. Aluminum has been found to be toxic to certain plants. A water quality standard for aluminum was established (U.S. Federal Water Pollution Control Administration, 1968) for interstate agricultural and irrigation waters, which set a trace element tolerance at 1 mg/l for continuous use on all soils and 20 mg/l for short term use on fine-textured soils.

Aluminum and some of its compounds used in food preparation and as food additives are generally recognized as safe and are sanctioned by the Food and Drug Administration. No limits on aluminum content in food and beverage products have been established.

There are no reported adverse physiological effects on man from low concentrations of aluminum in drinking water, however, large concentrations of aluminum in the human body are alleged to cause changes in behavior. Salts of aluminum are used as coagulants in water treatment, and in limited quantities do not have any adverse effects on POTW operations. Some aluminum salts are soluble, however, mildly alkaline conditions cause precipitation of aluminum as hydroxide. The precipitation of aluminum hydroxide can have an adverse effect on rooted aquatics and invertebrate benthos.

Iron. Iron is a non-conventional pollutant. It is an abundant metal found at many places in the earth's crust. The most common iron ore is hematite (Fe_2O_3) from which iron is obtained by reduction with carbon. Other forms of commercial ores are magnetite (Fe_3O_4) and taconite (FeSiO). Pure iron is not often found in commercial use, but it is usually alloyed with other metals and minerals. The most common of these is carbon.

Iron is the basic element in the production of steel. Iron with carbon is used for casting of major parts of machines and it can be machined, cast, formed, and welded. Ferrous iron is used in paints, while powdered iron can be sintered and used in powder metallurgy. Iron compounds are also used to precipitate other metals and undesirable minerals from industrial wastewater streams.

Corrosion products of iron in water cause staining of porcelain fixtures, and ferric iron combines with tannin to produce a dark violet color. The presence of excessive iron in water discourages cows from drinking and thus reduces milk production. High concentrations of ferric and ferrous ions in water kill most fish introduced to the solution within a few hours. The killing action is attributed to coatings of iron hydroxide precipitates on the gills. Iron oxidizing bacteria are dependent on iron in water for growth. These bacteria form slimes that can affect the aesthetic values of bodies of water and cause stoppage of flows in pipes.

Iron is an essential nutrient and micro-nutrient for all forms of growth. Drinking water standards in the U.S. set a limit of 0.3 mg/l of iron in domestic water supplies based on aesthetic and organoleptic properties of iron in water.

High concentrations of iron do not pass through a POTW into the effluent. In some POTW iron salts are added to coagulate precipitates and suspended sediments into a sludge. In an EPA study of POTW the concentrations of iron in the effluent of 22 biological POTW, meeting secondary treatment performance levels ranged from 0.048 to 0.569 mg/l with a median value of 0.25 mg/l. This represented removals of 76 to 97 percent with a median of 87 percent removal.

Iron in sewage sludge spread on land used for agricultural purposes is not expected to have a detrimental effect on crops grown on the land.

Manganese. Manganese is a non-conventional pollutant. It is a gray-white metal resembling iron, but more brittle. The pure metal does not occur in nature, but must be produced by reduction of the oxide with sodium, magnesium, or aluminum, or by electrolysis. The principal ores are pyrolusite (MnO_2) and psilomelane (a complex mixture of MnO_2 and oxides of potassium, barium and other alkali and alkaline earth metals). The largest percentage of manganese used in the U.S. is in ferro-manganese alloys. A small amount goes into dry batteries and chemicals.

Manganese is not often present in natural surface waters because its hydroxides and carbonates are only sparingly soluble.

tetrachloroethane by treatment with lime in the presence of water.

TCE is used for vapor phase degreasing of metal parts, cleaning and drying electronic components, as a solvent for paints, as a refrigerant, for extraction of oils, fats, and waxes, and for dry cleaning. Its widespread use and relatively high volatility result in detectable levels in many parts of the environment.

Data on the effects produced by ingested TCE are limited. Most studies have been directed at inhalation exposure. Nervous system disorders and liver damage are frequent results of inhalation exposure. In the short term exposures, TCE acts as a central nervous system depressant - it was used as an anesthetic before its other long term effects were defined.

TCE has been shown to induce transformation in a highly sensitive in vitro Fischer rat embryo cell system (F1706) that is used for identifying carcinogens. Severe and persistant toxicity to the liver was recently demonstrated when TCE was shown to produce carcinoma of the liver in mouse strain B6C3F1. One systematic study of TCE exposure and the incidence of human cancer was based on 518 men exposed to TCE. The authors of that study concluded that although the cancer risk to man cannot be ruled out, exposure to low levels of TCE probably does not present a very serious and general cancer hazard.

TCE is bioconcentrated in aquatic species, making the consumption of such species by humans a significant source of TCE. For the protection of human health from the potential carcinogenic effects of exposure to trichloroethylene through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of trichloroethylene estimated to result in additional lifetime cancer risk of 10^{-7}, 10^{-6}, and 10^{-5} are 2.7×10^{-4} mg/l, 2.7×10^{-3} mg/l, and 2.7×10^{-2} mg/l, respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 0.807 mg/l to keep the additional lifetime cancer risk below 10^{-5}.

Only a very limited amount of data on the effects of TCE on freshwater aquatic life are available. One species of fish (fathead minnows) showed a loss of equilibrium at concentrations below those resulting in lethal effects. The limited data for aquatic life show that adverse effects occur at concentrations higher than those cited for human health risks.

In laboratory scale studies of organic priority pollutants, TCE was subjected to biochemical oxidation conditions. After 5, 10, and 20 days no biochemical oxidation occurred. On the basis of this study and general observations relating molecular structure to ease of degradation, the conclusion is reached that TCE would undergo little or no biochemical oxidation by biological treatment in a POTW. The volatility and relatively low water solubility of TCE is expected to result in volatilization of some of the TCE in aeration steps in a POTW.

In an Agency study, Fate of Priority Pollutants in Publicly Owned Treatment Works, (EPA 440/1-30-301), the pollutant concentrations in the influent, effluent, and sludge of 20 POTW's were measured. No conclusions were made; however, trichloroethylene appeared in 95% of the influent stream samples but only in 54% of the effluent stream samples. This indicates that trichloroethylene either is concentrated in the sludge or escapes to the atmosphere. Concentrations in 50% of the sludge samples indicate that much of the trichloroethylene is concentrated there.

Cadmium(118). Cadmium is a relatively rare metallic element that is seldom found in sufficient quantities in a pure state to warrant mining or extraction from the earth's surface. It is found in trace amounts of about 1 ppm throughout the earth's crust. Cadmium is, however, a valuable by-product of zinc production.

Cadmium is used primarily as an electroplated metal, and is found as an impurity in the secondary refining of zinc, lead, and copper. Cadmium appears at a significant level in raw wastewaters from only one of the three subcategories of coil coating - galvanized. The presence of cadmium in the wastewater is attributed to its presence as an impurity in the zinc used to produce galvanized coil stock. Some of the zinc is removed by the cleaning and conversion coating steps.

Cadmium is an extremely dangerous cumulative toxicant, causing progressive chronic poisoning in mammals, fish, and probably other organisms. The metal is not excreted.

Toxic effects of cadmium on man have been reported from throughout the world. Cadmium may be a factor in the development of such human pathological conditions as kidney disease, testicular tumors, hypertension, arteriosclerosis, growth inhibition, chronic disease of old age, and cancer. Cadmium is normally ingested by humans through food and water as well as by breathing air contaminated by cadmium dust. Cadmium is cumulative in the liver, kidney, pancreas, and thyroid of humans and other animals. A severe bone and kidney syndrome known as itai-itai disease has been documented in Japan as caused by cadmium ingestion via drinking water and contaminated irrigation water. Ingestion of as little as 0.6 mg/day has produced the disease. Cadmium acts synergistically with other metals. Copper and zinc substantially increase its toxicity.

Cadmium is concentrated by marine organisms, particularly molluscs, which accumulate cadmium in calcareous tissues and in the viscera. A concentration factor of 1000 for cadmium in fish muscle has been reported, as have concentration factors of 3000 in marine plants and up to 29,600 in certain marine animals. The eggs and larvae of fish are apparently more sensitive than adult fish to poisoning by cadmium, and crustaceans appear to be more sensitive than fish eggs and larvae.

For the protection of human health from the toxic properties of cadmium ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 0.010 mg/l.

Cadmium is not destroyed when it is introduced into a POTW, and will either pass through to the POTW effluent or be incorporated into the POTW sludge. In addition, it can interfere with the POTW treatment process.

In a study of 189 POTW, 75 percent of the primary plants, 57 percent of the trickling filter plants, 66 percent of the activated sludge plants and 62 percent of the biological plants allowed over 90 percent of the influent cadmium to pass through to the POTW effluent. Only 2 of the 189 POTW allowed less than 20 percent pass-through, and none less than 10 percent pass-through. POTW effluent concentrations ranged from 0.001 to 1.97 mg/l (mean 0.028 mg/l, standard deviation 0.167 mg/l).

Cadmium not passed through the POTW will be retained in the sludge, where it is likely to build up in concentration. Cadmium contamination of sewage sludge limits its use on land since it increases the level of cadmium in the soil. Data show that cadmium can be incorporated into crops, including vegetables and grains, from contaminated soils. Since the crops themselves show no adverse effects from soils with levels up to 100 mg/kg cadmium, these contaminated crops could have a significant impact on human health. Two Federal agencies have already recognized the potential adverse human health effects posed by the use of sludge on cropland. The FDA recommends that sludge containing over 30 mg/kg of cadmium should not be used on agricultural land. Sewage sludge contains 3 to 300 mg/kg (dry basis) of cadmium mean = 10 mg/kg; median = 16 mg/kg. The USDA also recommends placing limits on the total cadmium from sludge that may be applied to land.

Chromium(119). Chromium is an elemental metal usually found as a chromite ($FeO \bullet Cr_2O_3$). The metal is normally produced by reducing the oxide with aluminum. A significant proportion of the chromium used is in the form of compounds such as sodium dichromate (Na_2CrO_4), and chromic acid (CrO_3) - both are hexavalent chromium compounds.

Chromium and its compounds are used extensively in the coil coating industry. As the metal, it is found as an alloying component of many steels.

The two chromium forms most frequently found in industry wastewaters are hexavalent and trivalent chromium. Hexavalaent chromium is the form used for metal treatments. Some of it is reduced to trivalent chromium as part of the process reaction. The raw wastewater containing both valence states is usually treated first to reduce remaining hexavalent to trivalent chromium, and second to precipitate the trivalent form as the hydroxide. The hexavalent form is not removed by lime treatment.

Chromium, in its various valence states, is hazardous to man. It can produce lung tumors when inhaled, and induces skin sensitizations. Large doses of chromates have corrosive effects on the intestinal tract and can cause inflammation of the kidneys. Hexavalent chromium is a known human carcinogen. Levels of chromate ions that show no effect in man appear to be so low as to prohibit determination, to date.

The toxicity of chromium salts to fish and other aquatic life varies widely with the species, temperature, pH, valence of the chromium, and synergistic or antagonistic effects, especially the effect of water hardness. Studies have shown that trivalent chromium is more toxic to fish of some types than is hexavalent chromium. Hexavalent chromium retards growth of one fish species at 0.0002 mg/l. Fish food organisms and other lower forms of aquatic life are extremely sensitive to chromium. Therefore, both hexavalent and trivalent chromium must be considered harmful to particular fish or organisms.

For the protection of human health from the toxic properties of chromium (except hexavalent chromium) ingested through water and contaminated aquatic organisms, the recommended water qualtiy criterion is 170 mg/l.

For the protection of human health from the toxic effects of exposure to hexavalent chromium through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero.

Chromium is not destroyed when treated by POTW (although the oxidation state may change), and will either pass through to the POTW effluent or be incorporated into the POTW sludge. Both oxidation states can inhibit POTW treatment and can also limit the usefuleness of municipal sludge.

EPA has observed influent concentrations of chromium to POTW facilities to range from 0.005 to 14.0 mg/l, with a median concentration of 0.1 mg/l. The efficiencies for removal of chromium by the activated sludge process can vary greatly, depending on chromium concentration in the influent, and other operating conditions at the POTW. Chelation of chromium by organic matter and dissolution due to the presence of carbonates can cause deviations from the predicted behavior in treatment systems.

The systematic presence of chromium compounds will halt nitrification in a POTW for short periods, and most of the chromium will be retained in the sludge solids. Hexavalent chromium has been reported to severely affect the nitrification process, but trivalent chromium has little or no toxicity to activated sludge, except at high concentrations. The presence of iron, copper, and low pH will increase the toxicity of chromium in a POTW by releasing the chromium into solution to be ingested by microorganisms in the POTW.

The amount of chromium which passes through to the POTW effluent depends on the type of treatment processes used by the POTW. In a study of 240 POTW's, 56 percent of the primary plants allowed more than 80 percent pass through to POTW effluent. More advanced treatment results in less pass-through. POTW effluent concentrations ranged from 0.003 to 3.2 mg/l total chromium (mean = 0.197, standard deviation = 0.48), and from 0.002 to 0.1 mg/l hexavalent chromium (mean = 0.017, standard deviation = 0.020).

Chromium not passed through the POTW will be retained in the sludge, where it is likely to build up in concentration. Sludge concentrations of total chromium of over 20,000 mg/kg (dry basis) have been observed. Disposal of sludges containing very high concentrations of trivalent chromium can potentially cause problems in uncontrollable landfills. Incineration, or similar destructive oxidation processes can produce hexavalent chromium from lower valance states. Hexavalent chromium is potentially more toxic than trivalent chromium. In cases where high rates of chrome sludge application on land are used, distinct growth inhibition and plant tissue uptake have been noted.

Pretreatment of discharges substantially reduces the concentration of chromium in sludge. In Buffalo, New York, pretreatment of electroplating waste resulted in a decrease in chromium concentrations in POTW sludge from 2,510 to 1,040 mg/kg. A similar reduction occurred in a Grand Rapids, Michigan, POTW where the chromium concentration in sludge decreased from 11,000 to 2,700 mg/kg when pretreatment was required.

Copper(120). Copper is a metallic element that sometimes is found free, as the native metal, and is also found in minerals such as cuprite (Cu_2O), malechite [$CuCO_3 \bullet Cu(OH)_2$], azurite [$2CuCO_3 \bullet Cu(OH)_2$], chalcopyrite ($CuFeS_2$), and bornite (Cu_5FeS_4). Copper is obtained from these ores by smelting, leaching, and electrolysis. It is used in the plating, electrical, plumbing, and heating equipment industries, as well as in insecticides and fungicides. In the coil coating industry copper can be attributed to various contaminant sources.

Traces of copper are found in all forms of plant and animal life, and the metal is an essential trace element for nutrition. Copper is not considered to be a cumulative systemic poison for humans because it is readily excreted by the body, but it can cause symptoms of gastroenteritis, with nausea and intestinal irritations, at relatively low dosages. The limiting factor in domestic water supplies is taste. To prevent this adverse organoleptic effect of copper in water, a criterion of 1 mg/l has been established.

The toxicity of copper to aquatic organisms varies significantly, not only with the species, but also with the physical and chemical characteristics of the water, including temperature, hardness, turbidity, and carbon dioxide content. In hard water, the toxicity of copper salts may be reduced by the precipitation of copper carbonate or other insoluble compounds. The sulfates of copper and zinc, and of copper and calcium are synergistic in their toxic effect on fish.

Relatively high concentrations of copper may be tolerated by adult fish for short periods of time; the critical effect of copper appears to be its higher toxicity to young or juvenile fish. Concentrations of 0.02 to 0.031 mg/l have proved fatal to some common fish species. In general the salmonoids are very sensitive and the sunfishes are less sensitive to copper.

The recommended criterion to protect saltwater aquatic life is 0.004 mg/l as a 24-hour average, and 0.023 mg/l maximum concentration.

Copper salts cause undesirable color reactions in the food industry and cause pitting when deposited on some other metals such as aluminum and galvanized steel.

Irrigation water containing more than minute quantities of copper can be detrimental to certain crops. Copper appears in all soils, and its concentration ranges from 10 to 80 ppm. In soils, copper occurs in association with hydrous oxides of manganese and iron, and also as soluble and insoluble complexes with organic matter. Copper is essential to the life of plants, and the normal range of concentration in plant tissue is from 5 to 20 ppm. Copper concentrations in plants normally do not build up to high levels when toxicity occurs. For example, the concentrations of copper in snapbean leaves and pods was less than 50 and 20 mg/kg, respectively, under conditions of severe copper toxicity. Even under conditions of copper toxicity, most of the excess copper accumulates in the roots; very little is moved to the aerial part of the plant.

Copper is not destroyed when treated by a POTW, and will either pass through to the POTW effluent or be retained in the POTW sludge. It can interfere with the POTW treatment processes and can limit the usefulness of municipal sludge.

The influent concentration of copper to POTW facilities has been observed by the EPA to range from 0.01 to 1.97 mg/l, with a median concentration of 0.12 mg/l. The copper that is removed from the influent stream of a POTW is adsorbed on the sludge or appears in the sludge as the hydroxide of the metal. Bench scale pilot studies have shown that from about 25 percent to 75 percent of the copper passing through the activated sludge process remains in solution in the final effluent. Four-hour slug dosages of copper sulfate in concentrations exceeding 50 mg/l were reported to have severe effects on the removal efficiency of an unacclimated system, with the system returning to normal in about 100 hours. Slug dosages of copper in the form of copper cyanide were observed to have much more severe effects on the activated sludge system, but the total system returned to normal in 24 hours.

In a recent study of 268 POTW, the median pass-through was over 80 percent for primary plants and 40 to 50 percent for trickling filter, activated sludge, and biological treatment plants. POTW effluent concentrations of copper ranged from 0.003 to 1.8 mg/l (mean 0.126, standard deviation 0.242).

Copper which does not pass through the POTW will be retained in the sludge where it will build up in concentration. The presence of excessive levels of copper in sludge may limit its use on cropland. Sewage sludge contains up to 16,000 mg/kg of copper, with 730 mg/kg as the mean value. These concentrations are significantly greater than those normally found in soil, which usually range from 18 to 80 mg/kg. Experimental data indicate that when dried sludge is spread over tillable land, the copper tends to remain in place down to the depth of tillage, except for copper which is taken up by plants grown in the soil. Recent investigation has shown that the extractable copper content of sludge-treated soil decreased with time, which suggests a reversion of copper to less soluble forms was occurring.

Cyanide(121). Cyanide compounds are widely used in the coil coating industry, primarily for accelerating action of chromating solutions.

Cyanides are among the most toxic of pollutants commonly observed in industrial wastewaters. Introduction of cyanide into industrial processes is usually by dissolution of potassium cyanide (KCN) or sodium cyanide (NaCN) in process waters; however, the hydrogen cyanide (HCN) formed when the above salts are dissolved in water is probably the most acutely lethal compound.

The relationship of pH to hydrogen cyanide formation is very important. As pH decreases below 7, more than 99 percent of the cyanide is present as HCN and less than 1 percent as cyanide ions. Thus, at neutral pH, that of most living organisms, the more toxic form of cyanide prevails.

Cyanide ions combine with numerous heavy metal ions to form complexes. The complexes are in equilibrium with HCN. Thus, the stability of the metal-cyanide complex and the pH determine the concentration of HCN. Stability of the metal-cyanide anion complexes is extremely variable. Those formed with zinc, copper, and cadmium are not stable - they rapidly dissociate, with production of HCN, in near neutral or acid waters. Some of the complexes are extremely stable. Cobaltocyanide is very resistant to acid distillation in the laboratory. Iron cyanide complexes are also stable, but undergo photodecomposition to give HCN upon exposure to sunlight. Synergistic effects have been demonstrated for the metal cyanide complexes making zinc, copper, and cadmium cyanides more toxic than an equal concentration of sodium cyanide.

The toxic mechanism of cyanide is essentially an inhibition of oxygen metabolism, i.e., rendering the tissues incapable of exchanging oxygen. The cyanogen compounds are true noncumulative protoplasmic poisons. They arrest the activity of all forms of animal life. Cyanide shows a very specific type of toxic action. It inhibits the cytochrome oxidase system. This system is the one which facilitates electron transfer from reduced metabolites to molecular oxygen. The human body can convert cyanide to a non-toxic thiocyanate and eliminate it. However, if the quantity of cyanide ingested is too great at one time, the inhibition of oxygen utilization proves fatal before the detoxifying reaction reduces the cyanide concentration to a safe level.

Cyanides are more toxic to fish than to lower forms of aquatic organisms such as midge larvae, crustaceans, and mussels. Toxicity to fish is a function of chemical form and concentration, and is influenced by the rate of metabolism (temperature), the level of dissolved oxygen, and pH. In laboratory studies free cyanide concentrations ranging from 0.05 to 0.15 mg/l have been proven to be fatal to sensitive fish species including trout, bluegill, and fathead minnows. Levels above 0.2 mg/l are rapidly fatal to most fish species. Long term sublethal concentrations of cyanide as low as 0.01 mg/l have been shown to affect the ability of fish to function normally, e.g., reproduce, grow, and swim.

For the protection of human health from the toxic properties of cyanide ingested through water and through contaminated aquatic organisms, the ambient water quality criterion is determined to be 0.200 mg/l.

Persistence of cyanide in water is highly variable and depends upon the chemical form of cyanide in the water, the concentration of cyanide, and the nature of other constituents. Cyanide may be destroyed by strong oxidizing agents such as permanganate and chlorine. Chlorine is commonly used to oxidize strong cyanide solutions. Carbon dioxide and nitrogen are the products of complete oxidation. But if the reaction is not complete, the very toxic compound; cyanogen chloride may remain in the treatment system and subsequently be released to the environment. Partial chlorination may occur as part of a POTW treatment, or during the disinfection treatment of surface water for drinking water preparation.

Cyanides can interfere with treatment processes in POTW, or pass through to ambient waters. At low concentrations and with acclimated microflora, cyanide may be decomposed by microorganisms in anaerobic and aerobic environments or waste treatment systems. However, data indicate that much of the cyanide introduced passes through to the POTW effluent. The mean pass-through of 14 biological plants was 71 percent. In a recent study of 41 POTW, the effluent concentrations ranged from 0.002 to 100 mg/l (mean = 2.518, standard deviation = 15.6). Cyanide also enhances the toxicity of metals commonly found in POTW effluents, including the priority pollutants cadmium, zinc, and copper.

Data for Grand Rapids, Michigan, showed a significant decline in cyanide concentrations downstream from the POTW after pretreatment regulations were put in force. Concentrations fell from 0.66 mg/l before, to 0.01 mg/l after pretreatment was required.

Lead (122). Lead is a soft, malleable ductible, bluish-gray, metallic element, usually obtained from the mineral galena (lead sulfide, PbS), anglesite (lead sulfate, $PbSO_4$), or cerussite (lead carbonate, $PbCO_3$). Because it is usually associated with the minerals zinc, silver, copper, gold, cadmium, antimony, and arsenic, special purification methods are frequently used before and after extraction of the metal from the ore concentrate by smelting.

Lead is widely used for its corrosion resistance, sound and vibration absorption, low melting point (solders), and relatively high imperviousness to various forms of radiation. Small amounts of copper, antimony and other metals can be alloyed with lead to achieve greater hardness, stiffness, or corrosion resistance than is afforded by the pure metal. Lead compounds are used in glazes and paints. About one third of U.S. lead consumption goes into storage batteries. About half of U.S. lead consumption is from secondary lead recovery. U.S. consumption of lead is in the range of one million tons annually.

Lead ingested by humans produces a variety of toxic effects including impaired reproductive ability, disturbances in blood chemistry, neurological disorders, kidney damage, and adverse cardiovascular effects. Exposure to lead in the diet results in permanent increase in lead levels in the body. Most of the lead entering the body eventually becomes localized in the bones where it accumulates. Lead is a carcinogen or cocarcinogen in some species of experimental animals. Lead is teratogenic in experimental animals. Mutangenicity data are not available for lead.

For the protection of human health from the toxic properties of lead ingested through water and through contaminated aquatic organisms, the ambient water criterion is 0.050 mg/l.

Lead is not destroyed in POTW, but is passed through to the effluent or retained in the POTW sludge; it can interfere with POTW treatment processes and can limit the usefulness of POTW sludge for application to agricultural croplands. Threshold concentration for inhibition of the activated sludge process is 0.1 mg/l, and for the nitrification process is 0.5 mg/l. In a study of 214 POTW, median pass through values were over 80 percent for primary plants and over 60 percent for trickling filter, activated sludge, and biological process plants. Lead concentration in POTW effluents ranged from 0.003 to 1.8 mg/l (means = 0.106 mg/l, standard deviation = 0.222).

Application of lead-containing sludge to cropland should not lead to uptake by crops under most conditions because normally lead is strongly bound by soil. However, under the unusual conditions of low pH (less than 5.5) and low concentrations of labile phosphorus, lead solubility is increased and plants can accumulate lead.

Nickel(124). Nickel is seldom found in nature as the pure elemental metal. It is a reltively plentiful element and is widely distributed throughout the earth's crust. It occurs in marine organisms and is found in the oceans. The chief commercial ores for nickel are pentlandite [$(Fe,Ni)_9S_8$], and a lateritic ore consisting of hydrated nickel-iron-magnesium silicate.

Nickel has many and varied uses. It is used in alloys and as the pure metal. Nickel salts are used for electroplating baths. The coil coating industry uses nickel compounds as accelerators in certain conversion coating solutions. Nickel is also found as a contaminant in mineral acids. It occurs in significant concentrations in the wastewaters from all three subcategories of coil coating.

The toxicity of nickel to man is thought to be very low, and systemic poisoning of human beings by nickel or nickel salts is almost unknown. In non-human mammals nickel acts to inhibit insulin release, depress growth, and reduce cholesterol. A high incidence of cancer of the lung and nose has been reported in humans engaged in the refining of nickel.

Nickel salts can kill fish at very low concentrations. However, nickel has been found to be less toxic to some fish than copper, zinc, and iron. Nickel is present in coastal and open ocean water at concentrations in the range of 0.0001 to 0.006 mg/l although the most common values are 0.002 - 0.003 mg/l. Marine animals contain up to 0.4 mg/l and marine plants contain up to 3 mg/l. Higher nickel concentrations have been reported to cause reduction in photosynthetic activity of the giant kelp. A low concentration was found to kill oyster eggs.

For the protection of human health based on the toxic properties of nickel ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 0.0134 mg/l.

Nickel is not destroyed when treated in a POTW, but will either pass through to the POTW effluent or be retained in the POTW sludge. It can interfere with POTW treatment processes and can also limit the usefulness of municipal sludge.

Nickel salts have caused inhibition of the biochemical oxidation of sewage in a POTW. In a pilot plant, slug doses of nickel significantly reduced normal treatment efficiencies for a few hours, but the plant acclimated itself somewhat to the slug dosage and appeared to achieve normal treatment efficiencies within 40 hours. It has been reported that the anaerobic digestion process is inhibited only by high concentrations of nickel, while a low concentration of nickel inhibits the nitrification process.

EPA has observed influent concentration of nickel to POTW facilities ranging from 0.01 to 3.19 mg/l, with a median of 0.33 mg/l. In a study of 190 POTW, nickel pass-through was greater than 90 percent for 82 percent of the primary plants. Median pass-through for trickling filter, activated sludge, and biological process plants was greater than 80 percent. POTW effuent concentrations ranged from 0.002 to 40 mg/l (mean = 0.410, standard deviation = 3.279).

Nickel not passed through the POTW will be incorporated into the sludge. In a recent two-year study of eight cities, four of the cities had median nickel concentrations of over 350 mg/kg, and two were over 1,000 mg/kg. . The maximum nickel concentration observed was 4,010 mg/kg.

Nickel is found in nearly all soils, plants, and waters. Nickel has no known essential function in plants. In soils, nickel typically is found in the range from 10 to 100 mg/kg. Various environmental exposures to nickel appear to correlate with increased incidence of tumors in man. For example, cancer in the maxillary antrum of snuff users may result from using plant material grown on soil high in nickel.

Nickel toxicity may develop in plants from application of sewage sludge on acid soils. Nickel has reduced yields for a variety of crops, including oats, mustard, turnips, and cabbage. In one study, nickel decreased the yields of oats significantly at 100 mg/kg.

Whether nickel exerts a toxic effect on plants depends on several soil factors, the amount of nickel applied, and the contents of other metals in the sludge. Unlike copper and zinc, which are more available from inorganic sources than from sludge, nickel uptake by plants seems to be promoted by the presence of the organic matter in sludge. Soil treatments such as liming reduce the solubility of nickel. Toxicity of nickel to plants is enhanced in acidic soils.

Zinc(128). Zinc occurs abundantly in the earth's crust, concentrated in ores. It is readily refined into the pure, stable, silvery-white metal. In addition to its use in alloys, zinc is used as a protective coating on steel. It is applied by hot dipping (i.e. dipping the steel in molten zinc) or by electroplating. The resulting galvanized steel is used as one of the basis materials for coil coating. Zinc salts are also used in conversion coatings in the coil coating industry.

Zinc can have an adverse effect on man and animals at high concentrations. Zinc at concentrations in excess of 5 mg/l causes an undesirable taste which persists through conventional treatment. For the prevention of adverse effects due to these organoleptic properties of zinc, 5 mg/l was adopted for the ambient water criterion.

Toxic concentrations of zinc compounds cause adverse changes in the morphology and physiology of fish. Lethal concentrations in the range of 0.1 mg/l have been reported. Acutely toxic concentrations induce cellular breakdown of the gills, and possibly the clogging of the gills with mucous. Chronically toxic concentrations of zinc compounds cause general enfeeblement and widespread histological changes to many organs, but not to gills. Abnormal swimming behavior has been reported at 0.04 mg/l. Growth and maturation are retarded by zinc. It has been observed that the effects of zinc poisoning may not become apparent immediately, so that fish removed from zinc-contaminated water may die as long as 48 hours after removal.

In general, salmonoids are most sensitive to elemental zinc in soft water; the rainbow trout is the most sensitive in hard waters. A complex relationship exists between zinc concentration, dissolved zinc concentration, pH, temperature, and calcium and magnesium concentration. Prediction of harmful effects has been less than reliable and controlled studies have not been extensively documented.

The major concern with zinc compounds in marine waters is not with acute lethal effects, but rather with the long-term sublethal effects of the metallic compounds and complexers. Zinc accumulates in some marine species, and marine animals contain zinc in the range of 6 to 1500 mg/kg. From the point of view of acute lethal effects, invertebrate marine animals seem to be the most sensitive organism tested.

Toxicities of zinc in nutrient solutions have been demonstrated for a number of plants. A variety of fresh water plants tested manifested harmful symptoms at concentrations of 10 mg/l. Zinc sulfate has also been found to be lethal to many plants and it could impair agricultural uses of the water.

Zinc is not destroyed when treated by POTW, but will either pass through to the POTW effluent or be retained in the POTW sludge. It can interfere with treatment processes in the POTW and can also limit the usefuleness of municipal sludge.

In slug doses, and particularly in the presence of copper, dissolved zinc can interfere with or seriously disrupt the operation of POTW biological processes by reducing overall removal efficiencies, largely as a result of the toxicity of the metal to biological organisms. However, zinc solids in the form of hydroxides or sulfides do not appear to interfere with biological treatment processes, on the basis of available data. Such solids accumulate in the sludge.

The influent concentrations of zinc to POTW facilities has been observed by the EPA to range from 0.017 to 3.91 mg/l, with a median concentration of 0.33 mg/l. Primary treatment is not efficient in removing zinc; however, the microbial floc of secondary treatment readily adsorbs zinc.

In a study of 258 POTW, the median pass-through values were 70 to 88 percent for primary plants, 50 to 60 percent for trickling filter and biological process plants, and 30-40 percent for activated process plants. POTW effluent concentrations of zinc ranged from 0.003 to 3.6 mg/l (mean = 0.330, standard deviation = 0.464).

The zinc which does not pass through the POTW is retained in the sludge. The presence of zinc in sludge may limit its use on cropland. Sewage sludge contains from 72 to over 30,000 mg/kg of zinc, with 3,366 mg/kg as the mean value. These concentrations are significantly greater than those normally found in soil, which range from 0 to 195 mg/kg, with 94 mg/kg being a common level. Therefore, application of sewage sludge to soil will generally increase the concentration of zinc in the soil. Zinc can be toxic to plants, depending upon soil pH. Lettuce, tomatoes, turnips, mustard, kale, and beets are especially sensitive to zinc contamination.

Aluminum. Aluminum is a non-conventional pollutant. It is a silvery white metal, very abundant in the earth's crust (8.1%), but never found free in nature. Its principal ore is bauxite. Alumina (Al_2O_3) is extracted from the bauxite and dissolved in molten cryolite. Aluminum is produced by electrolysis of this melt.

Aluminum is light, malleable, ductile, possesses high thermal and electrical conductivity, and is non-magnetic. It can be formed, machined or cast. Aluminum is used in the construction, transportation, and container industries and competes with iron and steel in these markets.

Aluminum had been found to be toxic to freshwater and marine aquatic life. In freshwaters acute toxicity and solubility increases as pH levels increase above pH 7. This relationship also appears to be true as the pH levels decrease below pH 7. Chronic effects of aluminum on aquatic life have also been documented. Aluminum has been found to be toxic to certain plants. A water quality standard for aluminum was established (U.S. Federal Water Pollution Control Administration, 1968) for interstate agricultural and irrigation waters, which set a trace element tolerance at 1 mg/l for continuous use on all soils and 20 mg/l for short term use on fine-textured soils.

Aluminum and some of its compounds used in food preparation and as food additives are generally recognized as safe and are sanctioned by the Food and Drug Administration. No limits on aluminum content in food and beverage products have been established.

There are no reported adverse physiological effects on man from low concentrations of aluminum in drinking water, however, large concentrations of aluminum in the human body are alleged to cause changes in behavior. Salts of aluminum are used as coagulants in water treatment, and in limited quantities do not have any adverse effects on POTW operations. Some aluminum salts are soluble, however, mildly alkaline conditions cause precipitation of aluminum as hydroxide. The precipitation of aluminum hydroxide can have an adverse effect on rooted aquatics and invertebrate benthos.

Iron. Iron is a non-conventional polluant. It is an abundant metal found at many places in the earth's crust. The most common iron ore is hematite (Fe_2O_3) from which iron is obtained by reduction with carbon. Other forms of commercial ores are magnetite (Fe_3O_4) and taconite (FeSiO). Pure iron is not often found in commercial use, but it is usually alloyed with other metals and minerals. The most common of these is carbon.

Iron is the basic element in the production of steel. Iron with carbon is used for casting of major parts of machines and it can be machined, cast, formed, and welded. Ferrous iron is used in paints, while powdered iron can be sintered and used in powder metallurgy. Iron compounds are also used to precipitate other metals and undesirable minerals from industrial wastewater streams.

Corrosion products of iron in water cause staining of porcelain fixtures, and ferric iron combines with tannin to produce a dark violet color. The presence of excessive iron in water discourages cows from drinking and thus reduces milk production. High concentrations of ferric and ferrous ions in water kill most fish introduced to the solution within a few hours. The killing action is attributed to coatings of iron hydroxide precipitates on the gills. Iron oxidizing bacteria are dependent on iron in water for growth. These bacteria form slimes that can affect the aesthetic values of bodies of water and cause stoppage of flows in pipes.

Iron is an essential nutrient and micro-nutrient for all forms of growth. Drinking water standards in the U.S. set a limit of 0.3 mg/l of iron in domestic water supplies based on aesthetic and organoleptic properties of iron in water.

High concentrations of iron do not pass through a POTW into the effluent. In some POTW iron salts are added to coagulate precipitates and suspended sediments into a sludge. In an EPA study of POTW the concentrations of iron in the effluent of 22 biological POTW, meeting secondary treatment performance levels ranged from 0.048 to 0.569 mg/l with a median value of 0.25 mg/l. This represented removals of 76 to 97 percent with a median of 87 percent removal.

Iron in sewage sludge spread on land used for agricultural purposes is not expected to have a detrimental effect on crops grown on the land.

Manganese. Manganese is a non-conventional pollutant. It is a gray-white metal resembling iron, but more brittle. The pure metal does not occur in nature, but must be produced by reduction of the oxide with sodium, magnesium, or aluminum, or by electrolysis. The principal ores are pyrolusite (MnO_2) and psilomelane (a complex mixture of MnO_2 and oxides of potassium, barium and other alkali and alkaline earth metals). The largest percentage of manganese used in the U.S. is in ferro-manganese alloys. A small amount goes into dry batteries and chemicals.

Manganese is not often present in natural surface waters because its hydroxides and carbonates are only sparingly soluble.

concentration considered to be achievable with available specific treatment methods. Therefore, 1,2-trans-dichloroethylene is not considered for specific regulation in this subcategory.

Isophorone concentrations appeared on 2 of 38 process sampling days in the galvanized subcategory. Both concentrations were from the same plant. Therefore, isophorone is not considered for specific regulation in this subcategory.

Naphthalene concentrations appeared on 10 of 38 process sampling days for the galvanized subcategory. The maximum concentration was 0.038 mg/l. This is lower than the concentration considered to be achievable with available specific treatment methods. Therefore, naphthalene is not considered for specific regulation in this subcategory.

Phenol concentrations did not appear on any of the 15 process sampling days for the galvanized subcategory. Therefore, phenol is not considered for specific regulation in this subcategory.

Toluene concentrations appeared on none of the 15 process sampling days for the galvanized subcategory. Therefore, toluene is not considered for specific regulation in this subcategory.

Aluminum Subcategory

Parameters Considered for Specific Regulation. Based on verification sampling results and a careful examination of the aluminum subcategory manufacturing processes and raw materials, twenty pollutant parameters were selected for consideration for specific regulation in effluent limitations and standards for this subcategory. The twenty are: bis(2-ethylhexyl)phthalate; butyl benzyl phthalate; di-n-butyl phthalate; di-n-octyl phthalate; diethyl phthalate; dimethyl phthalate; cadmium, chromium (total and hexavalent), copper, cyanide (total), lead, zinc, aluminum , iron, manganese, phenols (total), phosphorus, oil and grease, pH, and TSS. These pollutant parameters were found in raw wastewaters from the processes in this subcategory, and are amenable to control by identified wastewater treatment practices.

The six phthalate compounds bis(2-ethylhexyl)phthalate; butyl benzyl phthalate; di-n-butyl phthalate; di-n-octyl phthalate; diethyl phthalate; dimethyl phthalate; are considered as a group in this category. Bis(2-ethylhexyl) phthalate concentrations appeared on 33 of 42 process sampling days in the aluminum subcategory; the maximum concentration was 0.880 mg/l. Butyl benzyl phthalate concentrations appeared on 42 process sampling days in the aluminum subcategory; the maximum concentration was

0.015 mg/l. Di-n-butyl phthalate concentrations appeared on 10 of 42 process sampling days in the aluminum subcategory: the maximum concentration was 0.020 mg/l. Di-n-octyl phthalate concentrations appeared on 2 of 44 process sampling days in the aluminum subcategory; both of the concentrations were less than the analytical quantification limit.

Diethyl phthalate concentrations appeared on 31 of 42 process sampling days in the aluminum subcategory; the maximum concentration was 0.450 mg/l. Dimethyl phthalate concentrations appeared on 5 of 42 process sampling days in the aluminum subcategory; the maximum concentration was 0.110 mg/l. Because phthalate compounds are frequently found at treatable concentrations, all of the six phthalate compounds are considered for regulation in this subcategory.

Cadmium was found in 9 of 44 raw wastewater samples analyzed for this parameter for the aluminum subcategory. The maximum concentration was 0.270 mg/l. This concentration is greater than the concentration that can be achieved with specific treatment methods. Therefore, cadmium is considered for specific regulation in this subcategory.

Chromium (hexavalent) concentrations appeared on 13 of 43 process sampling days for the aluminum subcategory. The maximum concentration was 333.0 mg/l. Hexavalent chromium compounds are used in conversion coating formulations for this subcategory. All of the concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, hexavalent chromium is considered for specific regulation in this subcategory.

Copper concentrations appeared on 26 of 44 process sampling days for the aluminum subcategory. The maximum concentration was 0.980 mg/l. Several concentrations were greater than the level achievable with specific treatment methods. Therefore, copper is considered for specific regulation in this subcategory.

Cyanide (total) concentrations appeared on 35 of 44 process sampling days for the aluminum subcategory. The maximum concentration was 7.5 mg/l. Cyanide is a raw material for some conversion coating formulations used in this subcategory. Several of the concentrations were greater than the level achievable with specific treatment methods for cyanide destruction. Therefore, cyanide is considered for specific regulation in this subcategory.

Lead concentrations appeared on 9 of 44 process sampling days for the aluminum subcategory. The maximum concentration was

0.40 mg/l. All the lead concentrations were greater than the concentration level achievable with specific treatment methods. Therefore, lead is considered for specific regulation in this subcategory.

Zinc concentrations appeared on 42 of 44 process sampling days for the aluminum subcategory. The maximum concentration was 42.6 mg/l. Zinc is used in some conversion coating formulations in this subcategory. Several of the zinc concentrations were greater than the concentration level achievable with specific treatment methods. Therefore, zinc is considered for specific regulation in this subcategory.

Aluminum concentrations appeared on 32 of 44 process sampling days for the aluminum subcategory. The maximum concentration was 940 mg/l. Most of the concentrations were greater than the level achievable with specific treatment methods. Therefore, aluminum is considered for specific regulation in this subcategory.

Iron concentrations appeared on all 44 process sampling days for the aluminum subcategory. The maximum concentration was 86.9 mg/l. About half of the concentrations were greater than the level achievable with available specific treatment methods. Therefore, iron is considered for regulation in this subcategory.

Manganese concentrations appeared on 36 of 44 process sampling days for the aluminum subcategory. The maximum concentration was 14.7 mg/l. Nearly half of the concentrations are greater than the level achievable with specific treatment methods. Therefore, manganese is considered for specific regulation in this subcategory.

Phenols (Total) concentrations appeared on 34 of 44 process sampling days for the aluminum subcategory. The maximum concentration was 0.160 mg/l. Several of the concentrations are greater than the concentration considered to be achievable with available specific treatment methods. Therefore, Total Phenols is considered for specific regulation in this subcategory.

Phosphorus concentrations appeared on 19 of 29 process sampling days for the aluminum subcategory. The maximum concentration was 101.0 mg/l. Phosphates are used in cleaning formulations in the coil coating category. Half of the concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, phosphorus is considered for specific regulation in this subcategory.

The Oil and Grease concentrations appeared on in 33 of 44 process sampling days for the aluminum subcategory. The maximum concentration was 2800 mg/l. Several of the concentrations are greater than the level achievable with specific treatment methods. Therefore, Oil and Grease is considered for specific regulation in this subcategory.

pH ranged from 1.6 to 11.9 on the 44 process sampling days for the aluminum subcategory. pH can be controlled within the limits of 6 to 9 with specific treatment methods and therefore is considered for specific regulation in this subcategory.

Total suspended solids (TSS) concentrations appeared on 42 of 44 process sampling days for the aluminum subcategory. The maximum concentration was 1200 mg/l. Nearly half of the TSS concentrations are greater than the level achievable with specific treatment methods. Additionally, most of the metals are converted to precipitates by the specific treatment methods used to remove those pollutants. These toxic metal precipitates should not be discharged to POTW. Therefore, TSS is considered for specific regulation in this subcategory for direct and indirect dischargers.

Pollutant Parameters Not Considered for Specific Regulation. A total of ninteen pollutant parameters that were evaluated in verification sampling and analysis were dropped from further consideration for specific regulation in the aluminum subcategory. These parameters were found infrequently or at levels below those usually achieved by specific treatment methods. The nineteen are: fluoranthene; isophorone, naphthalene; phenol; 1,2-benzanthracene; benzo(a)pyrene; 3,4-benzofluoranthene; 11,12-benzofluoranthene; chrysene; acenaphthylene; anthracene; 1,12-benzoperylene; fluorene; phenanthrene; 1,2,5,6-dibenzanthracene; indeno(1,2,3-cd)pyrene; pyrene; toluene; and nickel.

Fluoranthene concentrations appeared on 1 of 42 process sampling days in the aluminum subcategory. The concentration was below the quantification limit. Therefore, fluoranthene is not considered for specific regulation in this subcategory.

Isophorone concentrations did not appear on any of 42 process sampling days in the aluminum subcategory. Therefore, isophorone is not considered for specific regulation in this subcategory.

Naphthalene concentrations appeared on 9 of 42 process sampling days in the aluminum subcategory. All concentrations were less than the quantification limit. Therefore, naphthalene is not considered for specific regulation in this subcategory.

Phenol concentrations did not appear on any of the process sampling days in the aluminum subcategory. Therefore, phenol is not considered for specific regulation in this subcategory.

Thirteen PAH - 1,2-benzanthracene; benzo(a)pyrene; 3,4,-benzofluoranthene; 11,12-benzofluoranthene; chrysene; acenaphthylene; anthracene; 1,12-benzoperylene; fluorene; phenanthrene; 1,2,5,6-dibenzanthracene; indeno(1,2,3-cd)pyrene; and pyrene are considered as a group. PAH concentrations appeared on 12 of 24 process sampling days in the aluminum subcategory. The maximum total PAH concentration was 0.020 mg/l, and no individual concentration was at or above the analytical quantification limit. None of the individual priority pollutant PAH is used as a raw material or as a process chemical in this subcategory. Some PAH may be removed with available treatment methods, the concentrations are so low that analytical methods could not readily and reliably establish whether or not removal occurred. Therefore, PAH are not considered for specific regulation in this subcategory.

Toluene was not detected on any of the process sampling days in the aluminum subcategory. Therefore, toluene is not considered for specific regulation in this subcategory.

Nickel concentrations appeared on 5 of 42 process sampling days in the aluminum subcategory. The maximum concentration was 0.26 mg/l. This concentration is lower than the level achievable with specific treatment methods. Therefore, nickel is not considered for specific regulation in this subcategory.

Summary

Table VI-1 (page 175) summarizes the selection of non-conventional and conventional pollutant parameters for consideration for specific regulation by subcategory. Table VI-2, (page 176) presents the results of selection of priority pollutant parameters for consideration for specific regulation for the steel, galvanized, and aluminum subcategories, respectively. The pollutants that were not detected (included by ND) include some pollutants which were detected in screening analysis of total raw wastewater, but which were not detected during verification analysis of raw wastewater from process steps within subcategories. "Environmentally Insignificant" includes parameters found in only one plant, present only below an environmentally significant level, or those that cannot be attributed to the point source category because they are generally found in plant equipment. "Not Treatable" means that concentrations were lower than the level achievable with the specific treatment methods considered in Section VII.

TABLE VI-1

NONCONVENTIONAL AND CONVENTIONAL POLLUTANT PARAMETERS SELECTED FOR CONSIDERATION FOR SPECIFIC REGULATION IN THE COIL COATING CATEGORY

Pollutant Parameter	Subcategory Steel	Galvanized	Aluminum
Aluminum	x	x	x
Iron	x	x	x
Manganese	x	x	x
Phenols, Total	x	x	x
Phosphorus	x	x	x
Oil & Grease	x	x	x
pH	x	x	x
TSS	x	x	x

TABLE VI-2
PRIORITY POLLUTANT DISPOSITION

			Subcategory	
Pollutant		Steel	Galvanized	Aluminum
001	Acenaphthene	ND	ND	ND
002	Acrolein	ND	ND	ND
003	Acrylonitrile	ND	ND	ND
004	Benzene	NQ	NQ	NQ
005	Benzidine	ND	ND	ND
006	Carbon tetrachloride (tetrachloromethane)	ND	ND	ND
007	Chlorobenzene	ND	ND	ND
008	1,2,4-trichlorobenzene	ND	ND	ND
009	Hexachlorobenzene	ND	ND	ND
010	1,2-dichloroethane	ND	ND	ND
011	1,1,1-trichloroethane	NT	NT	NT
012	Hexachloroethane	ND	ND	ND
013	1,1-dichloroethane	SU	NQ	ND
014	1,1,2-trichloroethane	ND	ND	ND
015	1,1,2,2-tetrachloroethane	ND	ND	ND
016	Chloroethane	ND	ND	ND
017	Bis (chloromethyl) ether	ND	ND	ND
018	Bis (2-chloroethyl) ether	ND	ND	ND
019	2-chloroethyl vinyl	ND	ND	ND
	ether (mixed)	ND	ND	ND
020	2-chloronaphthalene	ND	ND	ND
021	2,4,6-trichlorophenol	ND	ND	ND
022	Parachlorometa cresol	ND	ND	ND
023	Chloroform (trichloromethane)	ND	NQ	ND
024	2-chlorophenol	ND	ND	ND
025	1,2-dichlorobenzene	ND	ND	ND
026	1,3-dichlorobenzene	ND	ND	ND
027	1,4-dichlorobenzene	ND	ND	ND
028	3,3-dichlorobenzidine	ND	ND	ND
029	1,1-dichloroethylene	ND	NT	ND
030	1,2-trans-dichloroethylene	ND	NT	ND
031	2,4-dichlorophenol	ND	ND	ND
032	1,2-dichloropropane	ND	ND	ND
033	1,2-dichloropropylene	ND	ND	ND
	(1,3-dichloropropene)	ND	ND	ND

034	2,4-dimethylphenol	ND	ND	ND
035	2,4-dinitrotoluene	ND	ND	ND
036	2,6-dinitrotoluene	ND	ND	ND
037	1,2-diphenylhydrazine	ND	ND	ND
038	Ethylbenzene	NQ	NQ	NQ
039	Fluoranthene	RG	RG	NQ
040	4-chlorophenyl phenyl ether	ND	ND	ND
041	4-bromophenyl phenyl ether	ND	ND	ND
042	Bis(2-chloroisopropyl) ether	ND	ND	ND
043	Bis(2-chloroethoxyl) methane	ND	ND	ND
044	Methylene chloride (dichloromethane)	ND	ND	ND
045	Methyl chloride (dichloromethane)	ND	ND	ND
046	Methyl bromide (bromomethane)	ND	ND	ND
047	Bromoform (tribromomethane)	ND	ND	ND
048	Dichlorobromomethane	ND	ND	ND
049	Trichlorofluoromethane	ND	ND	ND
050	Dichlorodifluoromethane	ND	ND	ND
051	Chlorodibromomethane	ND	NQ	ND
052	Hexachlorobutadiene	ND	ND	ND
053	Hexachloromyclopentadiene	ND	ND	ND
054	Isophorone	SU	SU	ND
055	Naphthalene	NT	NT	NQ
056	Nitrobenzene	ND	ND	ND
057	2-nitrophenol	ND	ND	ND
058	4-nitrophenol	ND	ND	ND
059	2,4-dinitrophenol	ND	ND	ND
060	4,6-dinitro-o-cresol	ND	ND	ND
061	N-nitrosodimethylamine	ND	ND	ND
062	N-nitrosodipheylamine	ND	ND	ND
063	N-nitrosodi-n-propyl amine	ND	ND	ND
064	Pentachlorophenol	ND	ND	ND
065	Phenol	ND	ND	ND
066	Bis(2-ethylhexyl phthalate)	RG	RG	RG
067	Butyl benzylphthalate	RG	RG	RG
068	Di-N-Butyl Phthalate	RG	RG	RG

069	Di-n-octyl phthalate	SU	RG	RG
070	Diethyl phthalate	SU	RG	RG
071	Dimethyl phthalate	NQ	RG	RG
072	1,2-benzanthracene (benzo(a)anthracene)	RG	RG	NQ
073	Benzo(a)pyrene (3,4-benzopyrene)	RG	RG	RG
074	3,4-Benzofluoranthene (benzo(b)fluoranthene)	RG	RG	NQ
075	11,12-benzofluoranthene (benzo(b)fluoranthene)	RG	RG	NQ
076	Chrysene	RG	RG	NQ
077	Acenaphthylene	RG	RG	NQ
078	Anthracene	RG	RG	NQ
079	1,12-benzoperylene (benzo(ghi)perylene)	RG	RG	NQ
080	Fluorene	RG	RG	NQ
081	Phenanthrene	RG	RG	NQ
082	1,2,5,6-dibenzanthracene dibenzo(h)anthracene	RG	RG	NQ
083	Indeno(1,2,3-cd) pyren (2,3-o-pheynylene pyrene)	RG	RG	NQ
084	Pyrene	RQ	RQ	NQ
085	Tetrachloroethylene	NQ	NQ	NQ
086	Toluene	ND	ND	ND
087	Trichloroethylene	RG	RG	RG
088	Vinyl chloride (chloroethylene)	ND	ND	ND
089	Aldrin	ND	ND	ND
090	Dieldrin	ND	ND	ND
091	Chlordane (technical mixture and metabolites)	ND	ND	ND
092	4,4-DDT	ND	ND	ND
093	4,4-DDE (p,p-DDX)	ND	ND	ND
094	4,4-DDD (p,p-TDE)	ND	ND	ND
095	Alpha-endosulfan	ND	ND	ND
096	Beta-endosulfan	ND	ND	ND
097	Endosulfan sulfate	ND	ND	ND
098	Endrin	ND	ND	ND
099	Endrin aldehyde	ND	ND	ND
100	Heptachlor	ND	ND	ND
101	Heptachlor epoxide (BHC hexachloro-hexane)	ND	ND	ND
102	Alpha-BHC	ND	ND	ND
103	Beta-BHC	ND	ND	ND
104	Gamma-BHC (lindane)	ND	ND	ND

105	Delta-BHC (PCB-poly-chlorinated bi-phenyls)	ND	ND	ND
106	PCB-1232(Arochlor 1242)	ND	ND	ND
107	PCB-1254(Arochlor 1254	ND	ND	ND
108	PCB-1221(Arochlor 1221)	ND	ND	ND
109	PCB-1232(Arochlor 1232)	ND	ND	ND
110	PCB-1248(Arochlor 1248)	ND	ND	ND
111	PCB-1260(Arochlor 1260)	ND	ND	ND
112	PCB-1016(Arochlor 1016)	ND	ND	ND
113	Toxaphene	ND	ND	ND
114	Antimony	RG	ND	ND
115	Arsenic	ND	ND	ND
116	Asbestos	ND	ND	ND
117	Beryllium	ND	ND	ND
118	Cadmium	RG	RG	RG
119	Chromium	RG	RG	RG
120	Copper	NT	RG	RG
121	Cyanide	RG	RG	RG
122	Lead	RG	RG	RG
123	Mercury	ND	ND	ND
124	Nickel	RG	RG	RG
125	Selenium	ND	ND	ND
126	Silver	SU	ND	ND
127	Thallium	ND	ND	ND
128	Zinc	RG	RG	RG
129	2,3,7,8-tetrachlorodihenzo-p-dioxin (TCDD)	ND	ND	ND

LEGEND:

ND = NOT DETECTED
NQ = NOT QUANTIFIABLE
SU = SMALL, UNIQUE SOURCES
NT = NOT TREATABLE
RG = REGULATION CONSIDERED

SECTION VII

CONTROL AND TREATMENT TECHNOLOGY

This section describes the treatment techniques currently used or available to remove or recover wastewater pollutants normally generated by the coil coating industrial point source category. Included are discussions of individual end-of-pipe treatment technologies and in-plant technologies. These treatment technologies are widely used in many industrial categories and data and information to support their effectiveness has been drawn from a similarly wide range of sources and data bases.

END-OF-PIPE TREATMENT TECHNOLOGIES

Individual recovery and treatment technologies are described which are used or are suitable for use in treating wastewater discharges from coil coating facilities. Each description includes a functional description and discussions of application and performance, advantages and limitations, operational factors (reliability, maintainability, solid waste aspects), and demonstration status. The treatment processes described include both technologies presently demonstrated within the coil coating category, and technologies demonstrated in treatment of similar wastes in other industries.

Coil coating wastewater streams characteristically contain significant levels of toxic inorganics. Chromium, cyanide, lead, nickel, and zinc are found in coil coating wastewater streams at substantial concentrations. These toxic inorganic pollutants constitute the most significant wastewater pollutants in this category.

In general, these pollutants are removed by chemical precipitation and sedimentation or filtration. Most of them may be effectively removed by precipitation of metal hydroxides or carbonates utilizing the reaction with lime, sodium hydroxide, or sodium carbonate. For some, improved removals are provided by the use of sodium sulfide or ferrous sulfide to precipitate the pollutants as sulfide compounds with very low solubilities.

Discussion of end-of-pipe treatment technologies is divided into three parts: the major technologies; the effectiveness of major technologies; and minor end-of-pipe technologies.

MAJOR TECHNOLOGIES

In Sections IX, X, XI and XII, the rationale for selecting treatment systems is discussed. The individual technologies used in the system are described here. The major end-of-pipe technologies are: chemical reduction of hexavalent chromium, chemical precipitation of dissolved metals, cyanide precipitation, granular bed filtration, pressure filtration, settling of suspended solids, and skimming of oil. In practice, precipitation of metals and settling of the resulting precipitates is often a unified two-step operation. Suspended solids originally present in raw wastewaters are not appreciably affected by the precipitation operation and are removed with the precipitated metals in the settling operations. Settling operations can be evaluated independently of hydroxide or other chemical precipitation operations, but hydroxide and other chemical precipitation operations can only be evaluated in combination with a solids removal operation.

1. Chemical Reduction Of Chromium

Description of the Process. Reduction is a chemical reaction in which electrons are transferred to the chemical being reduced from the chemical initiating the transfer (the reducing agent). Sulfur dioxide, sodium bisulfite, sodium metabisulfite, and ferrous sulfate form strong reducing agents in aqueous solution and are often used in industrial waste treatment facilities for the reduction of hexavalent chromium to the trivalent form. The reduction allows removal of chromium from solution in conjunction with other metallic salts by alkaline precipitation. Hexavalent chromium is not precipitated as the hydroxide.

Gaseous sulfur dioxide is a widely used reducing agent and provides a good example of the chemical reduction process. Reduction using other reagents is chemically similar. The reactions involved may be illustrated as follows:

$$3\ SO_2 + 3\ H_2O \text{--------}> 3\ H_2SO_3$$

$$3\ H_2SO_3 + 2H_2CrO_4 \text{---}> Cr_2(SO_4)_3 + 5\ H_2O$$

The above reaction is favored by low pH. A pH of from 2 to 3 is normal for situations requiring complete reduction. At pH levels above 5, the reduction rate is slow. Oxidizing agents such as dissolved oxygen and ferric iron interfere with the reduction process by consuming the reducing agent.

A typical treatment consists of 45 minutes retention in a reaction tank. The reaction tank has an electronic recorder-controller device to control process conditions with respect to pH and oxidation reduction potential (ORP). Gaseous sulfur dioxide is metered to the reaction tank to maintain the ORP within the range of 250 to 300 millivolts. Sulfuric acid is added to maintain a pH level of from 1.8 to 2.0. The reaction tank is equipped with a propeller agitator designed to provide approximately one turnover per minute. Figure VII-13 (page 288) shows a continuous chromium reduction system.

Application and Performance. Chromium reduction is used in coil coating for treating chromating rinses for high-magnesium aluminum basis materials. Electroplating rinse waters and cooling tower blowdown are two major sources of chromium in waste streams. A study of an operational waste treatment facility chemically reducing hexavalent chromium has shown that a 99.7 percent reduction efficiency is easily achieved. Final concentrations of 0.05 mg/l are readily attained, and concentrations of 0.01 mg/l are considered to be attainable by properly maintained and operated equipment.

Advantages and Limitations. The major advantage of chemical reduction to reduce hexavalent chromium is that it is a fully proven technology based on many years of experience. Operation at ambient conditions results in low energy consumption, and the process, especially when using sulfur dioxide, is well suited to automatic control. Furthermore, the equipment is readily obtainable from many suppliers, and operation is straightforward.

One limitation of chemical reduction of hexavalent chromium is that for high concentrations of chromium, the cost of treatment chemicals may be prohibitive. When this situation occurs, other treatment techniques are likely to be more economical. Chemical interference by oxidizing agents is possible in the treatment of mixed wastes, and the treatment itself may introduce pollutants if not properly controlled. Storage and handling of sulfur dioxide is somewhat hazardous.

Operational Factors. Reliability: Maintenance consists of periodic removal of sludge, the frequency of which is a function of the input concentrations of detrimental constituents.

Solid Waste Aspects: Pretreatment to eliminate substances which will interfere with the process may often be necessary. This process produces trivalent chromium which can be controlled by further treatment. There may, however, be small amounts of sludge collected due to minor shifts in the solubility of the contaminants. This sludge can be processed by the main sludge treatment equipment.

Demonstration Status. The reduction of chromium waste by sulfur dioxide or sodium bisulfite is a classic process and is used by numerous plants which have hexavalent chromium compounds in wastewaters from operations such as electroplating and noncontact cooling.

2. Chemical Precipitation

Dissolved toxic metal ions and certain anions may be chemically precipitated for removal by physical means such as sedimentation, filtration, or centrifugation. Several reagents are commonly used to effect this precipitation.

1) Alkaline compounds such as lime or sodium hydroxide may be used to precipitate many toxic metal ions as metal hydroxides. Lime also may precipitate phosphates as insoluble calcium phosphate and fluorides as calcium fluoride.

2) Both "soluble" sulfides such as hydrogen sulfide or sodium sulfide and "insoluble" sulfides such as ferrous sulfide may be used to precipitate many heavy metal ions as insoluble metal sulfides.

3) Ferrous sulfate, zinc sulfate or both (as is required) may be used to precipitate cyanide as a ferro or zinc ferricyanide complex.

4) Carbonate precipitates may be used to remove metals either by direct precipitation using a carbonate reagent such as calcium carbonate or by converting hydroxides into carbonates using carbon dioxide.

These treatment chemicals may be added to a flash mixer or rapid mix tank, to a presettling tank, or directly to a clarifier or other settling device. Because metal hydroxides tend to be colloidal in nature, coagulating agents may also be added to facilitate settling. After the solids have been removed, final pH adjustment may be required to reduce the high pH created by the alkaline treatment chemicals.

Chemical precipitation as a mechanism for removing metals from wastewater is a complex process of at least two steps - precipitation of the unwanted metals and removal of the precipitate. Some small amount of metal will remain dissolved in the wastewater after complete precipitation. The amount of residual dissolved metal depends on the treatment chemicals used and related factors. The effectiveness of this method of removing any specific metal depends on the fraction of the specific metal in the raw waste (and hence in the precipitate) and the effectiveness of suspended solids removal. In specific instances, a sacrifical ion such as iron or aluminum may be added to aid in the precipitation process and reduce the fraction of a specific metal in the precipitate.

Application and Performance. Chemical precipitation is used in coil coating for precipitation of dissolved metals. It can be used to remove metal ions such as aluminum, antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, tin and zinc. The process is also applicable to any substance that can be transformed into an insoluble form such as fluorides, phosphates, soaps, sulfides and others. Because it is simple and effective, chemical precipitation is extensively used for industrial waste treatment.

The performance of chemical precipitation depends on several variables. The most important factors affecting precipitation effectiveness are:

1. Maintenance of an alkaline pH throughout the precipitation reaction and subsequent settling;
2. Addition of a sufficient excess of treatment ions to drive the precipitation reaction to completion;
3. Addition of an adequate supply of sacrificial ions (such as iron or aluminum) to ensure precipitation and removal of specific target ions; and
4. Effective removal of precipitated solids (see appropriate technologies discussed under "Solids Removal").

Control of pH. Irrespective of the solids removal technology employed, proper control of pH is absolutely essential for favorable performance of precipitation-sedimentation technologies. This is clearly illustrated by solubility curves for selected metals hydroxides and sulfides shown in Figure VII-1 (page 276), and by plotting effluent zinc concentrations against pH as shown in Figure VII-3 (page 262). Figure VII-3 was obtained from Development Document for the Proposed Effluent Limitations Guidelines and New Source Performance Standards for the Zinc Segment of Nonferrous Metals Manufacturing Point Source Category, U.S. E.P.A., EPA 440/1-74/033, November, 1974. Figure VII-3 was plotted from the sampling data from several facilities with metal finishing operations. It is partially illustrated by data obtained from 3 consecutive days of sampling at one metal processing plant (47432) as displayed in Table VII-1 (page 257).

Flow through this system is approximately 49,263 l/h (13,000 gal/hr).

This treatment system uses lime precipitation (pH adjustment) followed by coagulant addition and sedimentation. Samples were taken before (in) and after (out) the treatment system. The best treatment for removal of copper and zinc was achieved on day one, when the pH was maintained at a satisfactory level. The poorest treatment was found on the second day, when the pH slipped to an unacceptably low level and intermediate values were were achieved on the third day when pH values were less than desirable but in between the first and second days.

Sodium hydroxide is used by one facility (plant 439) for pH adjustment and chemical precipitation, followed by settling (sedimentation and a polishing lagoon) of precipitated solids. Samples were taken prior to caustic addition and following the polishing lagoon. Flow through the system is approximately 22,700 l/hr (6,000 gal/hr).

These data for this plant indicate that the system was operated efficiently. Effluent pH was controlled within the range of 8.6-9.3, and, while raw waste loadings were not unusually high, most toxic metals were removed to very low concentrations.

Lime and sodium hydroxide are sometimes used to precipitate metals. Data developed from plant 40063, a facility with a metal bearing wastewater, exemplify efficient operation of a chemical precipitation and settling system. Table VII-3 (page 258) shows sampling data from this system, which uses lime and sodium hydroxide for pH adjustment, chemical precipitation, polyelectrolyte flocculant addition, and sedimentation. Samples were taken of the raw waste influent to the system and of the clarifier effluent. Flow through the system is approximately 5,000 gal/hr.

At this plant, effluent TSS levels were below 15 mg/l on each day, despite average raw waste TSS concentrations of over 3500 mg/l. Effluent pH was maintained at approximately 8, lime addition was sufficient to precipitate the dissolved metal ions, and the flocculant addition and clarifier retention served to remove effectively the precipitated solids.

Sulfide precipitation is sometimes used to precipitate metals resulting in improved metals removals. Most metal sulfides are less soluble than hydroxides and the precipitates are frequently more dependably removed from water. Solubilities for selected metal hydroxide, carbonate and sulfide precipitates are shown in

Table VII-4 (page 259) (Source: Lange's Handbook of Chemistry). Sulfide precipitation is particularly effective in removing specific metals such as silver and mercury. Sampling data from three industrial plants using sulfide precipitation appear in Table VII-5 (page 260).

In all cases except iron, effluent concentrations are below 0.1 mg/l and in many cases below 0.01 mg/l for the three plants studied.

Sampling data from several chlorine-caustic manufacturing plants using sulfide precipitation demonstrate effluent mercury concentrations varying between 0.009 and 0.03 mg/l. As shown in Figure VII-2, (page 277) solubilities of PbS and Ag_2S are lower at alkaline pH levels than either the corresponding hydroxides or other sulfide compounds. This implies that removal performance for lead and silver sulfides should be comparable to or better than that for the heavy metal hydroxides. Bench scale tests on several types of metal finishing and manufacturing wastewater indicate that metals removal to levels of less than 0.05 mg/l and in some cases less than 0.01 mg/l are common in systems using sulfide precipitation followed by clarification. Some of the bench scale data, particularly in the case of lead, do not support such low effluent concentrations. However, lead is consistently removed to very low levels (less than 0.02 mg/l) in systems using hydroxide and carbonate precipitation and sedimentation.

Of particular interest is the ability of sulfide to precipitate hexavalent chromium (Cr^{+6}) without prior reduction to the trivalent state as is required in the hydroxide process. When ferrous sulfide is used as the precipitant, iron and sulfide act as reducing agents for the hexavalent chromium according to the reaction:

$$CrO_3 + FeS + 3H_2O \text{ ----> } Fe(OH)_3 + Cr(OH)_3 + S$$

The sludge produced in this reaction consists mainly of ferric hydroxides, chromic hydroxides and various metallic sulfides. Some excess hydroxyl ions are generated in this process, possibly requiring a downward re-adjustment of pH.

Based on the available data, Table VII-6 (page 261) shows the minimum reliably attainable effluent concentrations for sulfide precipitation-sedimentation systems. These values are used to calculate performance predictions of sulfide precipitation-sedimentation systems. Carbonate precipitation is sometimes used to precipitate metals, especially where precipitated metals values are to be recovered. The solubility of most metal carbonates is intermediate between hydroxide and sulfide solubilities; in addition, carbonates form easily filtered precipitates.

Carbonate ions appear to be particularly useful in precipitating lead and antimony. Sodium carbonate has been observed being added at treatment to improve lead precipitation and removal in some industrial plants. The lead hydroxide and lead carbonate solubility curves displayed in Figure VII-4 (page 279) ("Heavy Metals Removal," by Kenneth Lanovette, Chemical Engineering Deskbook Issue, Oct. 17, 1977) explain this phenomenon.

Coprecipitation With Iron- The presence of substantial quantites of iron in metal bearing wastewaters before treatment has been shown to improve the removal of toxic metals. In some cases this iron is an integral part of the industrial wastewater; in other cases iron is deliberately added as a pre or first step of treatment. The iron functions to improve toxic metal removal by three mechanisms: the iron co-precipitates with toxic metals forming a stable precipitate which desolubilizes the toxic metal; the iron improves the settleability of the precipitate; and the large amount of iron reduces the fraction of toxic metal in the precipitate. Co-precipitation with iron has been practiced for many years incidentally when iron was a substantial consitutent of raw wastewater and intentionally when iron salts were added as a coagulant aid. Aluminum or mixed iron-aluminum salt also have been used.

Co-precipitation using large amounts of ferrous iron salts is known as ferrite co-precipitation because magnetic iron oxide or ferrite is formed. The addition of ferrous salts (sulfate) is followed by alkali precipitation and air oxidation. The resultant precipitate is easily removed by filtration and may be removed magnetically. Data illustrating the performance of ferrite co-precipitation is shown in Table VII-7, (Page 262).

Advantages and Limitations

Chemical precipitation has proven to be an effective technique for removing many pollutants from industrial wastewater. It operates at ambient conditions and is well suited to automatic control. The use of chemical precipitation may be limited because of interference by chelating agents, because of possible chemical interference of mixed wastewaters and treatment chemicals, or because of the potentially hazardous situation involved with the storage and handling of those chemicals. Lime is usually added as a slurry when used in hydroxide precipitation. The slurry must be kept well mixed and the addition lines periodically checked to prevent blocking of the lines, which may result from a buildup of solids. Also, hydroxide precipitation usually makes recovery of the precipitated metals difficult, because of the heterogeneous nature of most hydroxide sludges.

The major advantage of the sulfide precipitation process is that the extremely low solubility of most metal sulfides promotes very high metal removal efficiencies; the sulfide process also has the ability to remove chromates and dichromates without preliminary reduction of the chromium to its trivalent state. In addition, sulfide can precipitate metals complexed with most complexing agents. The process demands care, however, in maintaining the pH of the solution at approximately 10 in order to prevent the generation of toxic hydrogen sulfide gas. For this reason, ventilation of the treatment tanks may be a necessary precaution in most installations. The use of insoluble sulfides reduces the problem of hydrogen sulfide evolution. As with hydroxide precipitation, excess sulfide ion must be present to drive the precipitation reaction to completion. Since the sulfide ion itself is toxic, sulfide addition must be carefully controlled to maximize heavy metals precipitation with a minimum of excess sulfide to avoid the necessity of post treatment. At very high excess sulfide levels and high pH, soluble mercury-sulfide compounds may also be formed. Where excess sulfide is present, aeration of the effluent stream can aid in oxidizing residual sulfide to the less harmful sodium sulfate (Na_2SO_4). The cost of sulfide precipitants is high in comparison with hydroxide precipitants, and disposal of metallic sulfide sludges may pose problems. An essential element in effective sulfide precipitation is the removal of precipitated solids from the wastewater and proper disposal in an appropriate site. Sulfide precipitation will also generate a higher volume of sludge, than hydroxide precipitation, resulting in higher disposal and dewatering costs. This is especially true when ferrous sulfide is used as the precipitant.

Sulfide precipitation may be used as a polishing treatment after hydroxide precipitation-sedimentation. This treatment configuration may provide the better treatment effectiveness of sulfide precipitation while minimizing the variability caused by changes in raw waste and reducing the amount of sulfide precipitant required.

Operational Factors. Reliability: Alkaline chemical precipitation is highly reliable, although proper monitoring and control are required. Sulfide precipitation systems provide similar reliability.

Maintainability: The major maintenance needs involve periodic upkeep of monitoring equipment, automatic feeding equipment, mixing equipment, and other hardware. Removal of accumulated sludge is necessary for efficient operation of precipitation-sedimentation systems.

Solid Waste Aspects: Solids which precipitate out are removed in a subsequent treatment step. Ultimately, these solids require proper disposal.

Demonstration Status. Chemical precipitation of metal hydroxides is a classic waste treatment technology used by most industrial waste treatment systems. Chemical precipitation of metals in the carbonate form alone has been found to be feasible and is commercially used to permit metals recovery and water reuse. Full scale commercial sulfide precipitation units are in operation at numerous installations. As noted earlier, sedimentation to remove precipitates is discussed separately.

Use in Coil Coating Plants. Chemical precipitation is used at 37 coil coating plants. The quality of treatment provided, however, is variable. A review of collected data and on-site observations reveals that control of system parameters is often poor. Where precipitates are removed by clarification, retention times are likely to be short and cleaning and maintenance questionable. Similarly, pH control is frequently inadequate. As a result of these factors, effluent performance at coil coating plants nominally practicing the same wastewater treatment is observed to vary widely.

3. Cyanide Precipitation

Cyanide precipitation, although a method for treating cyanide in wastewaters, does not destroy cyanide. The cyanide is retained in the sludge that is formed. Reports indicate that during exposure to sunlight the cyanide complexes can break down and form free cyanide. For this reason the sludge from this treatment method must be disposed of carefully.

Cyanide may be precipitated and settled out of wastewaters by the addition of zinc sulfate or ferrous sulfate. In the presence of iron, cyanide will form extremely stable cyanide complexes. The addition of zinc sulfate or ferrous sulfate forms zinc ferrocyanide or ferro and ferricyanide complexes.

Adequate removal of the precipitated cyanide requires that the pH must be kept at 9.0 and an appropriate retention time be maintained. A study has shown that the formation of the complex is very dependent on pH. At pH's of 8 and 10 the residual cyanide concentrations measured are twice those of the same reaction carried out at a pH of 9. Removal efficiencies also depend heavily on the retention time allowed. The formation of the complexes takes place rather slowly. Depending upon the excess amount of zinc sulfate or ferrous sulfate added, at least a 30 minute retention time should be allowed for the formation of the cyanide complex before continuing on to the clarification stage.

One experiment with an initial concentration of 10 mg/l of cyanide showed that 98 percent of the cyanide was complexed ten minutes after the addition of ferrous sulfate at twice the theoretical amount necessary. Interference from other metal ions, such as cadmium, might result in the need for longer retention times.

Table VII-8 (page 262) presents data from three coil coating plants. A fourth plant was visited for the purpose of observing plant testing of the cyanide precipitation system. Specific data from this facility are not included because: (1) the pH was usually well below the optimum level of 9.0; (2) the historical treatment data were not obtained using the standard cyanide analysis procedure; and (3) matched input-output data were not made available by the plant. Scanning the available data indicates that the raw waste CN level was in the range of 25.0; the pH 7.5; and treated CN level was from 0.1 to 0.2.

Plant 1057 allowed a 27 minute retention time for the formation of the complex. The retention time for the other plants is not known. The data suggest that over a wide range of cyanide concentration in the raw waste, the concentration of cyanide can be reduced in the effluent stream to under 0.07 mg/l.

Application and Performance. Cyanide precipitation can be used when cyanide destruction is not feasible because of the presence of cyanide complexes which are difficult to destroy. Effluent concentrations of cyanide well below 0.15 mg/l are possible.

Advantages and Limitations. Cyanide precipitation is an inexpensive method of treating cyanide. Problems may occur when metal ions interfere with the formation of the complexes.

Demonstration Status: Cyanide precipitation is used in at least six coil coating plants.

4. Granular Bed Filtration

Filtration occurs in nature as the surface ground waters are cleansed by sand. Silica sand, anthracite coal, and garnet are common filter media used in water treatment plants. These are usually supported by gravel. The media may be used singly or in combination. The multi-media filters may be arranged to maintain relatively distinct layers by virtue of balancing the forces of gravity, flow, and buoyancy on the individual particles. This is accomplished by selecting appropriate filter flow rates (gpm/sq-ft), media grain size, and density.

Granular bed filters may be classified in terms of filtration rate, filter media, flow pattern, or method of pressurization. Traditional rate classifications are slow sand, rapid sand, and high rate mixed media. In the slow sand filter, flux or hydraulic loading is relatively low, and removal of collected solids to clean the filter is therefore relatively infrequent. The filter is often cleaned by scraping off the inlet face (top) of the sand bed. In the higher rate filters, cleaning is frequent and is accomplished by a periodic backwash, opposite to the direction of normal flow.

A filter may use a single medium such as sand or diatomaceous earth, but dual and mixed (multiple) media filters allow higher flow rates and efficiencies. The dual media filter usually consists of a fine bed of sand under a coarser bed of anthracite coal. The coarse coal removes most of the influent solids, while the fine sand performs a polishing function. At the end of the backwash, the fine sand settles to the bottom because it is denser than the coal, and the filter is ready for normal operation. The mixed media filter operates on the same principle, with the finer, denser media at the bottom and the coarser, less dense media at the top. The usual arrangement is garnet at the bottom (outlet end) of the bed, sand in the middle, and anthracite coal at the top. Some mixing of these layers occurs and is, in fact, desirable.

The flow pattern is usually top-to-bottom, but other patterns are sometimes used. Upflow filters are sometimes used, and in a horizontal filter the flow is horizontal. In a biflow filter, the influent enters both the top and the bottom and exits laterally. The advantage of an upflow filter is that with an upflow backwash the particles of a single filter medium are distributed and maintained in the desired coarse-to-fine (bottom-to-top) arrangement. The disadvantage is that the bed tends to become fluidized, which ruins filtration efficiency. The biflow design is an attempt to overcome this problem.

The classic granular bed filter operates by gravity flow; however, pressure filters are fairly widely used. They permit higher solids loadings before cleaning and are advantageous when the filter effluent must be pressurized for further downstream treatment. In addition, pressure filter systems are often less costly for low to moderate flow rates.

Figure VII-14 (page 289) depicts a high rate, dual media, gravity downflow granular bed filter, with self-stored backwash. Both filtrate and backwash are piped around the bed in an arrangement that permits gravity upflow of the backwash, with the stored filtrate serving as backwash. Addition of the indicated coagulant and polyelectrolyte usually results in a substantial improvement in filter performance.

Auxilliary filter cleaning is sometimes employed in the upper few inches of filter beds. This is conventionally referred to as surface wash and is accomplished by water jets just below the surface of the expanded bed during the backwash cycle. These jets enhance the scouring action in the bed by increasing the agitation.

An important feature for successful filtration and backwashing is the underdrain. This is the support structure for the bed. The underdrain provides an area for collection of the filtered water without clogging from either the filtered solids or the media grains. In addition, the underdrain prevents loss of the media with the water, and during the backwash cycle it provides even flow distribution over the bed. Failure to dissipate the velocity head during the filter or backwash cycle will result in bed upset and the need for major repairs.

Several standard approaches are employed for filter underdrains. The simplest one consists of a parallel porous pipe imbedded under a layer of coarse gravel and manifolded to a header pipe for effluent removal. Other approaches to the underdrain system are known as the Leopold and Wheeler filter bottoms. Both of these incorporate false concrete bottoms with specific porosity configurations to provide drainage and velocity head dissipation.

Filter system operation may be manual or automatic. The filter backwash cycle may be on a timed basis, a pressure drop basis with a terminal value which triggers backwash, or a solids carry-over basis from turbidity monitoring of the outlet stream. All of these schemes have been used successfully.

Application and Performance. Wastewater treatment plants often use granular bed filters for polishing after clarification, sedimentation, or other similar operations. Granular bed filtration thus has potential application to nearly all industrial plants. Chemical additives which enhance the upstream treatment equipment may or may not be compatible with or enhance the filtration process. Normal operating flow rates for various types of filters are as follows:

Slow Sand	2.04 - 5.30 l/sq m-hr
Rapid Sand	40.74 - 51.48 l/sq m-hr
High Rate Mixed Media	81.48 - 122.22 l/sq m-hr

Suspended solids are commonly removed from wastewater streams by filtering through a deep 0.3-0.9 m (1-3 feet) granular filter bed. The porous bed formed by the granular media can be designed to remove practically all suspended particles. Even colloidal suspensions (roughly 1 to 100 microns) are adsorbed on the surface of the media grains as they pass in close proximity in the narrow bed passages.

Properly operated filters following some pretreatment to reduce suspended solids below 200 mg/l should produce water with less than 10 mg/l TSS. For example, multimedia filters produced the effluent qualities shown in Table VII-9 (page 263).

Advantages and Limitations. The principal advantages of granular bed filtration are its comparatively (to other filters) low initial and operating costs, reduced land requirements over other methods to achieve the same level of solids removal, and elimination of chemical additions to the discharge stream. However, the filter may require pretreatment if the solids level is high (over 100 mg/l). Operator training must be somewhat extensive due to the controls and periodic backwashing involved, and backwash must be stored and dewatered for economical disposal.

Operational Factors. Reliability: The recent improvements in filter technology have significantly improved filtration reliability. Control systems, improved designs, and good operating procedures have made filtration a highly reliable method of water treatment.

Maintainability: Deep bed filters may be operated with either manual or automatic backwash. In either case, they must be periodically inspected for media attrition, partial plugging, and leakage. Where backwashing is not used, collected solids must be removed by shoveling, and filter media must be at least partially replaced.

Solid Waste Aspects: Filter backwash is generally recycled within the wastewater treatment system, so that the solids ultimately appear in the clarifier sludge stream for subsequent dewatering. Alternatively, the backwash stream may be dewatered directly or, if there is no backwash, the collected solids may be disposed of in a suitable landfill. In either of these situations there is a solids disposal problem similar to that of clarifiers.

Demonstration Status. Deep bed filters are in common use in municipal treatment plants. Their use in polishing industrial clarifier effluent is increasing, and the technology is proven and conventional. Granular bed filtration is used in many manufacturing plants. As noted previously, however, little data is available characterizing the effectiveness of filters presently in use within the industry.

5. Pressure Filtration

Pressure filtration works by pumping the liquid through a filter material which is impenetrable to the solid phase. The positive pressure exerted by the feed pumps or other mechanical means provides the pressure differential which is the principal driving force. Figure VII-15 (page 290) represents the operation of one type of pressure filter.

A typical pressure filtration unit consists of a number of plates or trays which are held rigidly in a frame to ensure alignment and which are pressed together between a fixed end and a traveling end. On the surface of each plate is mounted a filter made of cloth or a synthetic fiber. The feed stream is pumped into the unit and passes through holes in the trays along the length of the press until the cavities or chambers between the trays are completely filled. The solids are then entrapped, and a cake begins to form on the surface of the filter material. The water passes through the fibers, and the solids are retained.

At the bottom of the trays are drainage ports. The filtrate is collected and discharged to a common drain. As the filter medium becomes coated with sludge, the flow of filtrate through the filter drops sharply, indicating that the capacity of the filter has been exhausted. The unit must then be cleaned of the sludge. After the cleaning or replacement of the filter media, the unit is again ready for operation.

Application and Performance. Pressure filtration is used in coil coating for sludge dewatering and also for direct removal of precipitated and other suspended solids from wastewater.

Because dewatering is such a common operation in treatment systems, pressure filtration is a technique which can be found in many industries concerned with removing solids from their waste stream.

In a typical pressure filter, chemically preconditioned sludge detained in the unit for one to three hours under pressures varying from 5 to 13 atmospheres exhibited final solids content between 25 and 50 percent.

Advantages and Limitations. The pressures which may be applied to a sludge for removal of water by filter presses that are currently available range from 5 to 13 atmospheres. As a result, pressure filtration may reduce the amount of chemical pretreatment required for sludge dewatering. Sludge retained in the form of the filter cake has a higher percentage of solids than that from centrifuge or vacuum filter. Thus, it can be easily accommodated by materials handling systems.

As a primary solids removal technique, pressure filtration requires less space than clarification and is well suited to streams with high solids loadings. The sludge produced may be disposed without further dewatering, but the amount of sludge is increased by the use of filter precoat materials (usually diatomaceous earth). Also, cloth pressure filters often do not achieve as high a degree of effluent clarification as clarifiers or granular media filters.

Two disadvantages associated with pressure filtration in the past have been the short life of the filter cloths and lack of automation. New synthetic fibers have largely offset the first of these problems. Also, units with automatic feeding and pressing cycles are now available.

For larger operations, the relatively high space requirements, as compared to those of a centrifuge, could be prohibitive in some situations.

Operational Factors. Reliability: With proper pretreatment, design, and control, pressure filtration is a highly dependable system.

Maintainability: Maintenance consists of periodic cleaning or replacement of the filter media, drainage grids, drainage piping, filter pans, and other parts of the system. If the removal of the sludge cake is not automated, additional time is required for this operation.

.Solid Waste Aspects: Because it is generally drier than other types of sludges, the filter sludge cake can be handled with relative ease. The accumulated sludge may be disposed by any of the accepted procedures depending on its chemical composition. The levels of toxic metals present in sludge from treating coil coating wastewater necessitate proper disposal.

Demonstration Status. Pressure filtration is a commonly used technology in a great many commercial applications.

6. Settling

Settling is a process which removes solid particles from a liquid matrix by gravitational force. This is done by reducing the velocity of the feed stream in a large volume tank or lagoon so that gravitational settling can occur. Figure VII-7 (page 266) shows two typical settling devices.

Settling is often preceded by chemical precipitation which converts dissolved pollutants to solid form and by coagulation which enhances settling by coagulating suspended precipitates into larger, faster settling particles.

If no chemical pretreatment is used, the wastewater is fed into a tank or lagoon where it loses velocity and the suspended solids are allowed to settle out. Long retention times are generally required. Accumulated sludge can be collected either periodically or continuously and either manually or mechanically. Simple settling, however, may require excessively large catchments, and long retention times (days as compared with hours) to achieve high removal efficiencies. Because of this, addition of settling aids such as alum or polymeric flocculants is often economically attractive.

In practice, chemical precipitation often precedes settling, and inorganic coagulants or polyelectrolytic flocculants are usually added as well. Common coagulants include sodium sulfate, sodium aluminate, ferrous or ferric sulfate, and ferric chloride. Organic polyelectrolytes vary in structure, but all usually form larger floc particles than coagulants used alone.

Following this pretreatment, the wastewater can be fed into a holding tank or lagoon for settling, but is more often piped into a clarifier for the same purpose. A clarifier reduces space requirements, reduces retention time, and increases solids removal efficiency. Conventional clarifiers generally consist of a circular or rectangular tank with a mechanical sludge collecting device or with a sloping funnel-shaped bottom designed for sludge collection. In advanced settling devices inclined plates, slanted tubes, or a lamellar network may be included within the clarifier tank in order to increase the effective settling area, increasing capacity. A fraction of the sludge stream is often recirculated to the inlet, promoting formation of a denser sludge.

Application and Performance. Settling and clarification are used in the coil coating category to remove precipitated metals. Settling can be used to remove most suspended solids in a particular waste stream; thus it is used extensively by many different industrial waste treatment facilities. Because most metal ion pollutants are readily converted to solid metal hydroxide precipitates, settling is of particular use in those industries associated with metal production, metal finishing, metal working, and any other industry with high concentrations of metal ions in their wastewaters. In addition to toxic metals, suitably precipitated materials effectively removed by settling include aluminum, iron, manganese, cobalt, antimony, beryllium, molybdenum, fluoride, phosphate, and many others.

A properly operating settling system can efficiently remove suspended solids, precipitated metal hydroxides, and other impurities from wastewater. The performance of the process depends on a variety of factors, including the density and particle size of the solids, the effective charge on the suspended particles, and the types of chemicals used in pretreatment. The site of flocculant or coagulant addition also may significantly influence the effectiveness of clarification. If the flocculant is subjected to too much mixing before entering the clarifier, the complexes may be sheared and the settling effectiveness diminished. At the same time, the flocculant must have sufficient mixing and reaction time in order for effective set-up and settling to occur. Plant personnel have observed that the line or trough leading into the clarifier is often the most efficient site for flocculant addition. The performance of simple settling is a function of the retention time, particle size and density, and the surface area of the basin.

The data displayed in Table VII-10 (page 263) indicate suspended solids removal efficiencies in settling systems.

The mean effluent TSS concentration obtained by the plants shown in Table VII-10 is 10.1 mg/l. Influent concentrations averaged 838 mg/l. The maximum effluent TSS value reported is 23 mg/l. These plants all use alkaline pH adjustment to precipitate metal hydroxides, and most add a coagulant or flocculant prior to settling.

Advantages and Limitations. The major advantage of simple settling is its simplicity as demonstrated by the gravitational settling of solid particulate waste in a holding tank or lagoon. The major problem with simple settling is the long retention time necessary to achieve complete settling, especially if the specific gravity of the suspended matter is close to that of water. Some materials cannot be practically removed by simple settling alone.

Settling performed in a clarifier is effective in removing slow-settling suspended matter in a shorter time and in less space than a simple settling system. Also, effluent quality is often better from a clarifier. The cost of installing and maintaining a clarifier, however, is substantially greater than the costs associated with simple settling.

Inclined plate, slant tube, and lamella settlers have even higher removal efficiencies than conventional clarifiers, and greater capacities per unit area are possible. Installed costs for these advanced clarification systems are claimed to be one half the cost of conventional systems of similar capacity.

Operational Factors. Reliability: Settling can be a highly reliable technology for removing suspended solids. Sufficient retention time and regular sludge removal are important factors affecting the reliability of all settling systems. Proper control of pH adjustment, chemical precipitation, and coagulant or flocculant addition are additional factors affecting settling efficiencies in systems (frequently clarifiers) where these methods are used.

Those advanced settlers using slanted tubes, inclined plates, or a lamellar network may require pre-screening of the waste in order to eliminate any fibrous materials which could potentially clog the system. Some installations are especially vulnerable to shock loadings, as by storm water runoff, but proper system design will prevent this.

Maintainability: When clarifiers or other advanced settling devices are used, the associated system utilized for chemical pretreatment and sludge dragout must be maintained on a regular basis. Routine maintenance of mechanical parts is also necessary. Lagoons require little maintenance other than periodic sludge removal.

Demonstration Status

Settling represents the typical method of solids removal and is employed extensively in industrial waste treatment. The advanced clarifiers are just beginning to appear in significant numbers in commercial applications. Sedimentation or clarification is used in many coil coating plants as shown below.

Settling Device	No. Plants
Settling Tanks	21
Clarifier	24
Tube or Plate Settler	4
Lagoon	6

Settling is used both as part of end-of-pipe treatment and within the plant to allow recovery of process solutions and raw materials.

7. Skimming

Pollutants with a specific gravity less than water will often float unassisted to the surface of the wastewater. Skimming removes these floating wastes. Skimming normally takes place in a tank designed to allow the floating debris to rise and remain on the surface, while the liquid flows to an outlet located below the floating layer. Skimming devices are therefore suited to the removal of non-emulsified oils from raw waste streams. Common skimming mechanisms include the rotating drum type, which picks up oil from the surface of the water as it rotates. A doctor blade scrapes oil from the drum and collects it in a trough for disposal or reuse. The water portion is allowed to flow under the rotating drum. Occasionally, an underflow baffle is installed after the drum; this has the advantage of retaining any floating oil which escapes the drum skimmer. The belt type skimmer is pulled vertically through the water, collecting oil which is scraped off from the surface and collected in a drum. Gravity separators, such as the API type, utilize overflow and underflow baffles to skim a floating oil layer from the surface of the wastewater. An overflow-underflow baffle allows a small amount of wastewater (the oil portion) to flow over into a trough for disposition or reuse while the majority of the water flows underneath the baffle. This is followed by an overflow baffle, which is set at a height relative to the first baffle such that only the oil bearing portion will flow over the first baffle during normal plant operation. A diffusion device, such as a vertical slot baffle, aids in creating a uniform flow through the system and increasing oil removal efficiency.

Application and Performance. Oil cleaned from the strip is a principal source of oil. Skimming is applicable to any waste stream containing pollutants which float to the surface. It is commonly used to remove free oil, grease, and soaps. Skimming is often used in conjunction with air flotation or clarification in order to increase its effectiveness.

The removal efficiency of a skimmer is partly a function of the retention time of the water in the tank. Larger, more buoyant particles require less retention time than smaller particles. Thus, the efficiency also depends on the composition of the waste stream. The retention time required to allow phase separation and subsequent skimming varies from 1 to 15 minutes, depending on the wastewater characteristics.

API or other gravity-type separators tend to be more suitable for use where the amount of surface oil flowing through the system is consistently significant. Drum and belt type skimmers are applicable to waste streams which evidence smaller amounts of floating oil and where surges of floating oil are not a problem. Using an API separator system in conjunction with a drum type skimmer would be a very effective method of removing floating contaminants from non-emulsified oily waste streams. Sampling data shown below illustrate the capabilities of the technology with both extremely high and moderate oil influent levels.

This data, displayed in Table VII-11 (page 264); is intended to be illustrative of the very high level of oil and grease removals attainable in a simple two stage oil removal system. Based on the performance of installations in a variety of manufacturing plants and permit requirements that are constantly achieved, it is determined that effluent oil levels may be reliably reduced below 10 mg/l with moderate influent concentrations. Very high concentrations of oil such as the 22 percent shown above may require two step treatment to achieve this level.

Skimming which removes oil may also be used to remove base levels of organics. Plant sampling data show that many organic compounds tend to be removed in standard wastewater treatment equipment. Oil separation not only removes oil but also organics that are more soluble in oil than in water. Clarification removes organic solids directly and probably removes dissolved organics by adsorption on inorganic solids.

The source of these organic pollutants is not always known with certainty, although in metal forming operations they seem to derive mainly from various process lubricants. They are also sometimes present in the plant water supply, as additives to proprietary formulations of cleaners, or due to leaching from plastic lines and other materials.

High molecular weight organics in particular are much more soluble in organic solvents than in water. Thus they are much more concentrated in the oil phase that is skimmed than in the wastewater. The ratio of solubilities of a compound in oil and water phases is called the partition coefficient. The logarithm of the partition coefficients for fifteen polynuclear aromatic hydrocarbon (PAH) compounds in octanol and water are listed in Table VII-12 (page 84).

A study of priority organic compounds commonly found in metal forming operations waste streams indicated that incidental removal of these compounds often occurs as a result of oil removal or clarification processes. When all organics analyses from visited plants are considered, removal of organic compounds by other waste treatment technologies appears to be marginal in many cases. However, when only raw waste concentrations of 0.05 mg/l or greater are considered incidental organics removal becomes much more apparent. Lower values, those less than 0.05 mg/l, are much more subject to analytical variation, while higher values indicate a significant presence of a given compound. When these factors are taken into account, analysis data indicate that most clarification and oil removal treatment systems remove significant amounts of the organic compounds present in the raw waste. The API oil-water separation system and the thermal emulsion breaker (TEB) performed notably in this regard, as shown in the following table (all values in mg/l).

Data from five plant days demonstrate removal of organics by the combined oil skimming and settling operations performed on coil coating wastewaters. Days were chosen where treatment system influent and effluent analyses provided paired data points for oil and grease and the organics present. All organics found at quantifiable levels on those days were included. Further, only those days were chosen where oil and grease raw wastewater concentrations exceeded 10 mg/l and where there was reduction in oil and grease going through the treatment system. All plant sampling days which met the above criteria are included below. The conclusion is that when oil and grease are removed, organics are removed, also.

	Percent Removal	
Plant-Day	Oil & Grease	Organics
1054-3	95.9	98.2
13029-2	98.3	78.0
13029-3	95.1	77.0
38053-1	96.8	81.3
38053-2	98.5	86.3
Mean	96.9	84.2

The unit operation most applicable to removal of trace priority organics is adsorption, and chemical oxidation is another possibility. Biological degradation is not generally applicable because the organics are not present in sufficient concentration to sustain a biomass and because most of the organics are resistant to biodegradation.

Advantages and Limitations. Skimming as a pretreatment is effective in removing naturally floating waste material. It also improves the performance of subsequent downstream treatments.

Many pollutants, particularly dispersed or emulsified oil, will not float "naturally" but require additional treatments. Therefore, skimming alone may not remove all the pollutants capable of being removed by air flotation or other more sophisticated technologies.

Operational Factors. Reliability: Because of its simplicity, skimming is a very reliable technique.

Maintainability: The skimming mechanism requires periodic lubrication, adjustment, and replacement of worn parts.

Solid Waste Aspects: The collected layer of debris must be disposed of by contractor removal, landfill, or incineration. Because relatively large quantities of water are present in the collected wastes, incineration is not always a viable disposal method.

Demonstration Status. Skimming is a common operation utilized extensively by industrial waste treatment systems. Oil skimming is used in seven coil coating plants.

MAJOR TECHNOLOGY EFFECTIVENESS

The performance of individual treatment technologies was presented above. Performance of operating systems is discussed here. Two different systems are considered: L&S (hydroxide precipitation and sedimentation or lime and settle) and LS&F (hydroxide precipitation, sedimentation and filtration or lime, settle, and filter). Subsequently, an analysis of effectiveness of such systems is made to develop one-day maximum, and ten-day and thirty-day average concentration levels to be used in regulating pollutants. Evaluation of the L&S and the LS&F systems is carried out on the assumption that chemical reduction of chromium, cyanide precipitation, and oil skimming are installed and operating properly where appropriate.

L&S PERFORMANCE -- COMBINED METALS DATA BASE

Before proposal, chemical analysis data were collected of raw waste (treatment influent) and treated waste (treatment effluent) from 55 plants (126 data days) sampled by EPA (or its contractor) using EPA sampling and chemical analysis protocols. These data are the data base for determining the effectiveness of L&S technology. Each of these plants belongs to at least one of the following industry categories: aluminum forming, battery manufacturing, coil coating, copper forming, electroplating and porcelain enameling. All of the plants employ pH adjustment and hydroxide precipitation using lime or caustic, followed by settling (tank, lagoon or clarifier) for solids removal. Most also add a coagulant or flocculant prior to solids removal.

An analysis of this data was presented in the development documents for the proposed regulations for coil coating and porcelain enameling (January 1981). In response to the proposal, some commenters claimed that it was inappropriate to use data from some categories for regulation of other categories. In response to these comments, the Agency reanalyzed the data. An analysis of variance was applied to the data for the 126 days of sampling to test the hypothesis of homogeneous plant mean raw and treated effluent levels across categories by pollutant. This analysis is described in the report "A Statistical Analysis of the Combined Metals Industries Effluent Data" which is in the administrative record supporting this rulemaking. The main conclusion drawn from the analysis of variance is that, with the exception of electroplating, the categories are generally homogeneous with regard to mean pollutant concentrations in both raw and treated effluent. That is, when data from electroplating facilities are included in the analysis, the hypothesis of homogeneity across categories is rejected. When the electroplating data are removed from the analysis the conclusion changes substantially and the hypothesis of homogeneity across categories is not rejected. On the basis of this analysis, the electroplating data were removed from the data base used to determine limitations. Cases that appeared to be marginally different were not unexpected (such as copper in copper forming and lead in lead battery manufacturing) were accommodated in developing limitations by using the larger values obtained from the marginally different category to characterize the entire data set.

The statistical analysis provides support for the technical engineering judgment that electroplating wastewaters are different from most metal processing wastewaters. These differences may be further explained by differences in the relative amounts of pollutants in the raw wastewaters.

Therefore, the wastewater data derived from plants that only electroplate are not used in developing limitations for the coil coating category.

After removing the electroplating data, data from 21 plants and 52 days of sampling remained. Eleven of these plants and 25 days of sampling are from coil coating operations.

For the purpose of developing treatment effectiveness, certain data were deleted from the data base. Before examination for homogeneity the first two data items below were removal; the third data item was removed after the homogeneity examination. These deletions were made to ensure that the data reflect properly operated treatment systems and actual pollutant removal. The following criteria were used in making these deletions:

- Plants where malfunctioning processes or treatment systems at time of sampling were identified.
- Data days where pH was less than 7.0 or TSS was greater than 50 mg/l. (This is a prima facia indication of poor operation).
- Data points where the raw waste value was too low to assure actual pollutant removal occurred (i.e., less than 0.1 mg/l of pollutant in raw waste).

Collectively, these selection criteria insure that the data are from properly operating lime and settle treatment facilities. The remaining data are displayed graphically in Figures VII-8 to VII-16 (Pages 283-291). This common or combined metals data base provides a more sound and usable basis for estimating treatment effectiveness and statistical variability of lime and settle technology than the available data from any one category.

One-day Effluent Values

The basis assumption underlying the determination of treatment effectiveness is that the data for a particular pollutant are lognormally distributed by plant. The lognormal has been found to provide a satisfactory fit to plant effluent data in a number of effluent guidelines categories. In the case of the combined metal categories data base, there are too few data from any one plant to verify formally the lognormal assumption. Thus, we assumed measurements of each pollutant from a particular plant, denoted by X, followed a lognormal distribution with log mean μ and log variance σ^2. The mean, variance and 99th percentile of X are then:

$$\text{mean of } X = E(X) = \exp(\mu + \sigma^2/2)$$

$$\text{variance of } X = V(X) = \exp(2\mu + \sigma^2)\,[\exp(\sigma^2)-1]$$

$$\text{99th percentile} = X_{.99} = \exp(\mu + 2.33\,\sigma)$$

where exp is e, the base of the natural logarithm. The term lognormal is used because the logarithm of X has a normal distribution with mean μ and variance σ^2. Using the basic assumption of lognormality the actual treatment effectiveness was determined using a lognormal distribution that, in a sense, approximates the distribution of an average of the plants in the data base, i.e., an "average plant" distribution. The notion of an "average plant" distribution is not a strict statistical concept but is used here to determine limits that would represent the performance capability of an average of the plants in the data base.

This "average plant" distribution for a particular pollutant was developed as follows: the log mean was determined by taking the average of all the observations for the pollutant across plants. The log variance was determined by the pooled within plant variance. This is the weighted average of the plant variances. Thus, the log mean represents the average of all the data for the pollutant and the log variance represents the average of the plant log variances or average plant variability for the pollutant.

The one day effluent values were determined as follows:

Let X_{ij} = the jth observation on a particular pollutant at plant i where

$i = 1, \ldots, I$
$j = 1, \ldots, J_i$
I = total number of plants
J_i = number of observations at plant i.

Then $y_{ij} = \ln X_{ij}$

where ln means the natural logarithm.

Then $\bar{y}$ = log mean over all plants

$$= \sum_{i=1}^{I} \sum_{j=1}^{J_i} y_{ij}/n,$$

where n = total number of observations

$$= \sum_{i=1}^{I} J_i$$

and $V(y)$ = pooled log variance

$$= \frac{\sum_{i=1}^{I} (J_i - 1)\, S_i^2}{\sum_{i=1}^{I} (J_i - 1)}$$

where S_i^2 = log variance at plant i

$$= \sum_{j=1}^{J_i} (y_{ij} - \overline{y}_i)^2/(J_i - 1)$$

$\overline{y}_i$ = log mean at plant i.

Thus, y and V(y) are the log mean and log variance, respectively, of the lognormal distribution used to determine the treatment effectiveness. The estimated mean and 99th percentile of this distribution form the basis for the long term average and daily maximum effluent limitations, respectively. The estimates are

$$\text{mean} = \hat{E}(X) = \exp(\overline{y})\, \psi_n\, (0.5\, V(y))$$

$$\text{99th percentile} = \hat{X}_{.99} = \exp[\overline{y} + 2.33 \sqrt{V(y)}\,]$$

where ψ (.) is a Bessel function and exp is e, the base of the natural logarithms (See Aitchison, J. and J.A.C. Brown, The Lognormal Distribution, Cambridge University Press, 1963). In cases where zeros were present in the data, a generalized form of the lognormal, known as the delta distribution was used (See Aitchison and Brown, op. cit., Chapter 9).

For certain pollutants, this approach was modified slightly to accommodate situations in which a category or categories stood out as being marginally different from the others. For instance, after excluding the electroplating data and other data that did not reflect pollutant removal or proper treatment, the effluent copper data from the copper forming plants were statistically significantly greater than the copper data from the other plants. Thus, copper effluent values shown in Table VII-14 (page 265) are based only on the copper effluent data from the copper forming plants. That is, the log mean for copper is the mean of the logs of all copper values from the copper forming plants only and the log variance is the pooled log variance of the copper forming plant data only. In the case of cadmium, after excluding the electroplating data and data that did not reflect removal or proper treatment, there were insufficient data to estimate the log variance for cadmium. The variance used to determine the values shown in Table VII-13 for cadmium was estimated by pooling the within plant variances for all the other metals. Thus, the cadmium variability is the average of the plant variability averaged over all the other metals. The log mean for cadmium is the mean of the logs of the cadmium observations only. A complete discussion of the data and calculations for all the metals is contained in the administrative record for this rulemaking.

Average Effluent Values

Average effluent values that form the basis for the monthly limitations were developed in a manner consistent with the method used to develop one day treatment effectiveness in that the lognormal distribution used for the one-day effluent values was also used as the basis for the average values. That is, we assume a number of consecutive measurements are drawn from the distribution of daily measurements. The approach used for the 10 measurements values was employed previously for the electroplating category (see "Development document for Existing Sources Pretreatment Standards for the Electroplating Point Source Category" EPA 440/1-79/003, U.S. Environmental Protection Agency, Washington, D.C., August, 1979). That is, the distribution of the average of 10 samples from a lognormal was approximated by another lognormal distribution. Although the approximation is not precise theoretically, there is empirical evidence based on effluent data from a number of categories that the lognormal is an adequate approximation for the distribution of small samples. In the course of previous work the approximation was verified in a computer simulation study. We also note that the average values were developed assuming independence of the observations although no particular sampling scheme was assumed.

Ten-Sample average:

The formulas for the 10-sample limitations were derived on the basis of simple relationships between the mean and variance of the distributions of the daily pollutant measurements and the average of 10 measurements. We assume the daily concentration measurements for a particular pollutant, denoted by X, follow a lognormal distribution with log mean and log variance denoted by μ and σ^2, respectivey. Let X_{10} denote the mean of 10 consecutive measurements. The following relationships then hold assuming the daily measurements are independent:

$$\text{mean of } \overline{X}_{10} = E(\overline{X}_{10}) = E(X)$$

$$\text{variance of } \overline{X}_{10} = V(\overline{X}_{10}) = V(X) + 10.$$

Where E(X) and V(X) are the mean and variance of X, respectively, defined above. We then assume that X_{10} follows a lognormal distribution with log mean U_{10} and log standard deviation o_{10}. The mean and variance of X_{10} are then

$$\overline{E}(X_{10}) = \exp\ (\mu\ 10 + 0.5\ \sigma^{2}{}_{10})$$
$$V(X_{10}) = \exp\ (2\ \mu\ 10 + \sigma^{2}{}_{10})\ [\exp(\ \sigma^{2}{}_{10}) - 1]$$

Now, μ 10 and $\sigma^{2}{}_{10}$ can be derived in terms of μ and σ^2 as

$$\mu\ 10 = \mu + \sigma^{2}/2 + 0.5 \quad \ln\ [1 + (\exp\ (\ \sigma^{2}) - 1)/N]$$
$$\sigma_{10} = \ln\ [1 + (\exp(\ \sigma^{2}\ ) - 1)/N]$$

Therefore, μ_{10} and $\sigma^{2}{}_{10}$ can be estimated using the above relationships and the estimates of μ and σ^2 obtained for the underlying lognormal distribution. The 10 sample limitation value was determined by the estimate of the approximate 99th percentile of the distribution of the 10 sample average given by

$$\hat{X}_{10}\ (.99) = \exp\ (\hat{\mu}_{10} + 2.33\ \hat{\sigma}_{10}).$$

where $\hat{\mu}$ 10 and $\hat{\sigma}_{10}$ are the estimates of μ_{10} and σ_{10}, respectively.

30 Sample Average:

The average values based on 30 measurements are determined on the basis of a statistical result known as the Central Limit Theorem. This Theorem states that, under general and nonrestrictive assumptions, the distribution of a sum of a number of random variables, say n, is approximated by the normal distribution. The approximation improves as the number of variables, n, increases. The Theorem is quite general in that no particular distributional form is assumed for the distribution of the individual variables. In most applications (as in approximating the distribution of 30-day averages) the Theorem is used to approximate the distribution of the average of n observations of a random variable. The result makes it possible to compute approximate probability statements about the average in a wide range of cases. For instance, it is possible to compute a value below which a specified percentage (e.g., 99 percent) of the averages of n observations are likely to fall. Most textbooks state that 25 or 30 observations are sufficient for the approximation to be valid. In applying the Theorem to the distribution of the 30 day average effluent values, we approximate the distribution of the average of 30 observations drawn from the distribution of daily measurements and use the estimated 99th percentile of this distribution. The monthly limitations based on 10 consecutive measurements were determined using the lognormal approximation described above because 10 measurements was, in this case, considered too small a number for use of the Central Limit Theorem.

30 Sample Average Calculation

The formulas for the 30 sample average were based on an application of the Central Limit Theorem. According to the Theorem, the average of 30 observations drawn from the distribution of daily measurements, denoted by X_{30}, is approximately normally distributed. The mean and variance of X_{30} are:

$$\text{mean of } \overline{X}_{30} = E(\overline{X}_{30}) = E(X)$$
$$\text{variance of } \overline{X}_{30} = V(\overline{X}_{30}) = V(X)/30.$$

The 30 sample average value was determined by the estimate of the approximate 99th percentile of the distribution of the 30 sample average given by

$$\widehat{X_{30}(.99)} = \hat{E}(X) = 2.33 \sqrt{\hat{V}(X) \div 30}$$

where
$$\hat{E}(X) = \exp(\overline{y})\ \psi_n\ (0.5V(y))$$
and
$$\hat{V}(X) = \exp(2\overline{y})\ [\ \psi_n(2V(y)) - \psi_n\left(\left(\frac{n-2}{n-1}\right)V(y)\right)].$$

The formulas for E(X) and V(X) are estimates of E(X) and V(X) respectively given in Aitchison, J. and J.A.C. Brown, The Lognormal Distribution, Cambridge University Press, 1963, page 45.

Application

In response to the proposed coil coating and porcelain enameling regulations, the Agency received comments pointing out that permits usually required less than 30 samples to be taken during a month while the monthly average used as the basis for permits and pretreatment requirements usually is based on the average of 30 samples.

In applying the treatment effectiveness values to regulations we have considered the comments, examined the sampling frequency required by many permits and considered the change in values of averages depending on the number of consecutive sampling days in the averages. The most common frequency of sampling required in permits is about ten samples per month or slightly greater than twice weekly. The 99th percentiles of the distribution of averages of ten consecutive sampling days are not substantially different from the 99th percentile of the distribution's 30 day average. (Compared to the one-day maximum, the ten-day average is about 80 percent of the difference between one and 30 day values). Hence the ten day average provides a reasonable basis for a monthly average limitation and is typical of the sampling frequency required by existing permits.

The monthly average limitation is to be achieved in all permits and pretreatment standards regardless of the number of samples required to be analyzed and averaged by the permit or the pretreatment authority.

Additional Pollutants

A number of other pollutant parameters were considered with regard to the performance of lime and settle treatment systems in removing them from industrial wastewater. Performance data for these parameters is not readily available, so data available to the Agency in other categories has been selectively used to determine the long term average. Performance of lime and settle technology for each pollutant. These data indicate that the concentrations shown in Table VII-15 (page 266) are reliably attainable with hydroxide precipitation and settling. The precipitation of silver appears to be accomplished by alkaline chloride precipitation and adequate chloride ions must be available for this reaction to occur.

In establishing which data were suitable for use in Table VII-15 two factors were heavily weighed; (1) the nature of the wastewater; (2) and the range of pollutants or pollutant matrix in the raw wastewater. These data have been selected from processes that generate dissolved metals in the wastewater and which are generally free from complexing agents. The pollutant matrix was evaluated by comparing the concentrations of pollutants found in the raw wastewaters with the range of pollutants in the raw wastewaters of the combined metals data set. These data are displayed in Tables VII-16 (page 266) and VII-17 (page 267) and indicate that there is sufficient similarity in the raw wastes to logically assume transferability of the treated pollutant concentrations to the combined metals data base. The available date on these added pollutants do not allow homogeneity analysis as was performed on the combined metals data base. The data source for each added pollutant is discussed separately.

Antimony (Sb) - The achievable performance for antimony is based on data from a battery and secondary lead plant. Both EPA sampling data and recent permit data (1978-1982) confirm the achievability of 0.7 mg/l in the battery manufacturing wastewater matrix included in the combined data set.

Arsenic (As) - The achievable performance of 0.5 mg/l for arsenic is based on permit data from two nonferrous metals manufacturing plants. The untreated wastewater matrix shown in Table VII-17 is comparable with the combined data set matrix.

Beryllium (Be) - The treatability of beryllium is transferred from the nonferrous metals manufacturing industry. The 0.3 performance is achieved at a beryllium plant with the comparable untreated wastewater matrix shown in Table VII 17.

Mercury (Hg) - The 0.06 mg/l treatability of mercury is based on data from four battery plants. The untreated wastewater matrix at these plants was considered in the combined metals data set.

Selenium (Se) - The 0.30 mg/l treatability of selenium is based on recent permit data from one of the nonferrous metals manufacturing plants also used for antimony performance. The untreated wastewater matrix for this plant is shown in Table VII-17.

Silver - The treatability of silver is based on a 0.1 mg/l treatability estimate from the inorganic chemicals industry. Additional data supporting a treatability as stringent or more stringent than 0.1 mg/l is also available from seven nonferrous metals manufacturing plants. The untreated wastewater matrix for these plants is comparable and summarized in Table VII-1& (page 267).

Thallium (Tl) - The 0.50 mg/l treatability for thallium is transferred from the inorganic chemicals industry. Although no untreated wastewater data are available to verify comparability with the combined metals data set plants, no other sources of data for thallium treatability could be identified.

Aluminum (Al) - The 1.11 mg/l treatability of aluminum is based on the mean performance of one aluminum forming plant and one coil coating plant. Both of the plants are from categories considered in the combined metals data set, assuring untreated wastewater matrix comparability.

Cobalt (Co) - The 0.05 mg/l treatability is based on nearly complete removal of cobalt at a porcelain enameling plant with a mean untreated wastewater cobalt concentration of 4.31 mg/l. In this case, the analytical detection using aspiration techniques for this pollutant is used as the basis of the treatability. Porcelain enameling was considered in the combined metals data base, assuring untreated wastewater matrix comparability.

Fluoride (F) - The 14.5 mg/l treatability of fluoride is based on the mean performance of an electronics and electrical component manufacturing plant. The untreated wastewater matrix for this plant shown in Table VII-17 is comparable to the combined metals data set.

L,S&F PERFORMANCE

Tables VII-18 and VII-19 (pages 268-269) show long term data from two plants which have well operated precipitation-settling treatment followed by filtration. The wastewaters from both plants contain pollutants from metals processing and finishing operations (multi-category). Both plants reduce hexavalent chromium before neutralizing and precipitating metals with lime. A clarifier is used to remove much of the solids load and a filter is used to "polish" or complete removal of suspended solids. Plant A uses a pressure filter, while Plant B uses a rapid sand filter.

Raw waste data was collected only occasionally at each facility and the raw waste data is presented as an indication of the nature of the wastewater treated. Data from plant A was received as a statistical summary and is presented as received. Raw laboratory data was collected at plant B and reviewed for spurious points and discrepancies. The method of treating the data base is discussed below under lime, settle, and filter treatment effectiveness.

Table VII-20 (Page 270) shows long-term data for zinc and cadmium removal at Plant C, a primary zinc smelter, which operates a LS&F system. This data represents about 4 months (103 data days) taken immediately before the smelter was closed. It has been arranged similarily to Plants A and B for comparison and use.

These data are presented to demonstrate the performance of precipitation-settling-filtration (LS&F) technology under actual operating conditions and over a long period of time.

It should be noted that the iron content of the raw waste of plants A and B is high while that for Plant C is low. This results, for plants A and B, in coprecipitation of toxic metals with iron. Precipitation using high-calcium lime for pH control yields the results shown above. Plant operating personnel indicate that this chemical treatment combination (sometimes with polymer assisted coagulation) generally produces better and more consistant metals removal than other combinations of sacrificial metal ions and alkalis.

The LS&F performance data presented here are based on systems that provide polishing filtration after effective L&S treatment. We have previously shown that L&S treatment is equally applicable to wastewaters from the five categories because of the homogeneity of its raw and treated wastewaters, and other factors. Because of the similarity of the wastewaters after L&S treatment, the Agency believes these wastewaters are equally amenable to treatment using polishing filters added to the L&S treatment system. The Agency concludes that LS&F data based on porcelain enameling and non-ferrous smelting and refining is directly applicable to the aluminum forming, copper forming, battery manufacturing, coil coating, and metal molding and casting categories, as well as to the porcelain enameling and nonferrous melting and refining.

ANALYSIS OF TREATMENT SYSTEM EFFECTIVENESS

Data are presented in Table VII-14 (page 265) showing the mean, one day, 10 day, and 30 day values for nine pollutants examined in the L&S metals data base. The mean variability factor for eight pollutants (excluding cadmium because of the small number of data points) was determined and is used to estimate one day, 10 day and 30 day values. (The variability factor is the ratio of the value of concern to the mean: the average variability factors are: one day maximum - 4.100; ten day average - 1.821; and 30 day average - 1.618.) For values not calculated from the common data base as previously discussed, the mean value for pollutants shown in Table VII-15 were multiplied by the variability factors to derive the value to obtain the one, ten and 30 day values. These are tabulated in Table VII-21 (page 271).

LS&F technology data are presented in Tables VII-18 and VII-19 (pages 268-269). These data represent two operating plants (A and B) in which the technology has been installed and operated for some years. Plant A data was received as a statistical summary and is presented without change. Plant B data was received as raw laboratory analysis data. Discussions with plant personnel indicated that operating experiments and changes in materials and reagents and occasional operating errors had occured during the data collection period. No specific information was available on those variables. To sort out high values probably caused by methodological factors from random statistical variability, or data noise, the plant B data were analyzed. For each of four pollutants (chromium, nickel, zinc, and iron), the mean and standard deviation (sigma) were calculated for the entire data set. A data day was removed from the complete data set when any individual pollutant concentration for that day exceeded the sum of the mean plus three sigma for that pollutant. Fifty-one data days (from a total of about 1300) were eliminated by this method.

Another approach was also used as a check on the above method of eliminating certain high values. The minimum values of raw wastewater concentrations from Plant B for the same four pollutants were compared to the total set of values for the corresponding pollutants. Any day on which the pollutant concentration exceeded the minimum value selected from raw wastewater concentrations for that pollutant was discarded. Forty-five days of data were eliminated by that procedure. Forty-three days of data in common were eliminated by either procedures. Since common engineering practice (mean plus 3 sigma) and logic (treated waste should be less than raw waste) seem to coincide, the data base with the 51 spurious data days eliminated is the basis for all further analysis. Range, mean, standard deviation and mean plus two standard deviations are shown in Tables VII-18 and VII-19 for Cr, Cu, Ni, Zn and Fe.

The Plant B data was separated into 1979, 1978, and total data base (six years) segments. With the statistical analysis from Plant A for 1978 and 1979 this in effect created five data sets in which there is some overlap between the individual years and total data sets from Plant B. By comparing these five parts it is apparent that they are quite similar and all appear to be from the same family of numbers. The largest mean found among the five data sets for each pollutant was selected as the long term mean for LS&F technology and is used as the LS&F mean in Table VII-21.

Plant C data was used as a basis for cadmium removal performance and as a check on the zinc values derived from Plants A and B. The cadmium data is displayed in Table VII-20 (page 270) and is incorporated into Table VII-21 for LS&F. The zinc data was analyzed for compliance with the 1-day and 30-day values in Table VII-20; no zinc value of the 103 data points exceeded the 1-day zinc value of 1.02 mg/l. The 103 data points were separated into blocks of 30 points and averaged. Each of the 3 full 30-day averages was less than the Table VII-21 value of 0.31 mg/l. Additionally the Plant C raw wastewater pollutant concentrations (Table VII-20) are well within the range of raw wastewater concentrations of the combined metals data base (Table VII-15), further supporting the conclusion that Plant C wastewater data is compatible with similar data from Plants A and B.

Concentration values for regulatory use are displayed in Table VII-21. Mean one day, ten day and 30 day values for L&S for nine pollutants were taken from Table VII-13; the remaining L&S values were developed using the mean values in Table VII-15 and the mean variability factors discussed above.

LS&F mean values for Cd, Cr, Ni, Zn and Fe are derived from plants A, B, and C as discussed above. One, ten and thirty day values are derived by applying the variability factor developed from the pooled data base for the specific pollutant to the mean for that pollutant. Other LS&F values are calculated using the long term average or mean and the appropriate variability factors. Mean values for LS&F for pollutants not already discussed are derived by reducing the L&S mean by one-third. The one-third reduction was established after examining the percent reduction in concentrations going from L&S to LS&F data for Cd, Cr, Ni, Zn, and Fe. The average reduction is 0.3338 or one third.

Copper levels achieved at Plants A and B may be lower than generally achievable because of the high iron content and low copper content of the raw wastewaters. Therefore, the mean concentration value achieved is not used; LS&F mean used is derived from the L&S technology.

L&S cyanide mean levels shown in Table VII-8 are ratioed to one day, ten day and 30 day values using mean variability factors. LS&F mean cyanide is calculated by applying the ratios of removals L&S and LS&F as discussed previously for LS&F metals limitations. The cyanide performance was arrived at by using the average metal variability factors. The treatment method used here is cyanide precipitation. Because cyanide precipitation is limited by the same physical processes as the metal precipitation, it is expected that the variabilities will be similar. Therefore, the average of the metal variability factors has been used as a basis for calculating the cyanide one day, ten day and thirty day average treatment effectiveness values.

The filter performance for removing TSS as shown in Table VII-9 yields a mean effluent concentration of 2.61 mg/l and calculates to a 10 day average of 4.33, 30 day average of 3.36 mg/l; a one day maximum of 8.88. These calculated values more than amply support the classic values of 10 and 15, respectively, which are used for LS&F.

Although iron was reduced in some LS&F operations, some facilities using that treatment introduce iron compounds to aid settling. Therefore, the one day, ten day and 30 day values for iron at LS&F were held at the L&S level so as to not unduly penalize the operations which use the relatively less objectionable iron compounds to enhance removals of toxic metals.

MINOR TECHNOLOGIES

Several other treatment technologies were considered for possible application in BPT or BAT. These technologies are presented here with a full discussion for most of them. A few are described only briefly because of limited technical development.

8. Carbon Adsorption

The use of activated carbon to remove dissolved organics from water and wastewater is a long demonstrated technology. It is one of the most efficient organic removal processes available. This sorption process is reversible, allowing activated carbon to be regenerated for reuse by the application of heat and steam or solvent. Activated carbon has also proved to be an effective adsorbent for many toxic metals, including mercury. Regeneration of carbon which has adsorbed significant metals, however, may be difficult.

The term activated carbon applies to any amorphous form of carbon that has been specially treated to give high adsorption capacities. Typical raw materials include coal, wood, coconut shells, petroleum base residues and char from sewage sludge pyrolysis. A carefully controlled process of dehydration, carbonization, and oxidation yields a product which is called activated carbon. This material has a high capacity for adsorption due primarily to the large surface area available for adsorption, 500-1500 m^2/g resulting from a large number of internal pores. Pore sizes generally range from 10-100 angstroms in radius.

Activated carbon removes contaminants from water by the process of adsorption, or the attraction and accumulation of one substance on the surface of another. Activated carbon preferentially adsorbs organic compounds and, because of this selectivity, is particularly effective in removing organic compounds from aqueous solution.

Carbon adsorption requires pretreatment to remove excess suspended solids, oils, and greases. Suspended solids in the influent should be less than 50 mg/l to minimize backwash requirements; a downflow carbon bed can handle much higher levels (up to 2000 mg/l), but requires frequent backwashing. Backwashing more than two or three times a day is not desirable; at 50 mg/l suspended solids one backwash will suffice. Oil and grease should be less than about 10 mg/l. A high level of dissolved inorganic material in the influent may cause problems with thermal carbon reactivation (i.e., scaling and loss of activity) unless appropriate preventive steps are taken. Such steps might include pH control, softening, or the use of an acid wash on the carbon prior to reactivation.

Activated carbon is available in both powdered and granular form. An adsorption column packed with granular activated carbon is shown in Figure VII-17 (page 292). Powdered carbon is less expensive per unit weight and may have slightly higher adsorption capacity, but it is more difficult to handle and to regenerate.

Application and Performance. Carbon adsorption is used to remove mercury from wastewaters. The removal rate is influenced by the mercury level in the influent to the adsorption unit. Removal levels found at three manufacturing facilities are shown in Table VII-24. In the aggregate these data indicate that very low effluent levels could be attained from any raw waste by use of multiple adsorption stages. This is characteristic of adsorption processes.

Isotherm tests have indicated that activated carbon is very effective in adsorbing 65 percent of the organic priority pollutants and is reasonably effective for another 22 percent. Specifically, for the organics of particular interest, activated carbon was very effective in removing 2,4-dimethylphenol, fluoranthene, isophorone, naphthalene, all phthalates, and phenanthrene. It was reasonably effective on 1,1,1-trichloroethane, 1,1-dichloroethane, phenol, and toluene. Table VII-22 (page 272) summarizes the treatability rating for most of the organic priority pollutants by activated carbon as compiled by EPA. Table VII-23 (page 273) summarizes classes of organic compounds together with examples of organics that are readily adsorbed on carbon.

Advantages and Limitations. The major benefits of carbon treatment include applicability to a wide variety of organics, and high removal efficiency. Inorganics such as cyanide, chromium, and mercury are also removed effectively. Variations in concentration and flow rate are well tolerated. The system is compact, and recovery of adsorbed materials is sometimes practical. However, destruction of adsorbed compounds often occurs during thermal regeneration. If carbon cannot be thermally desorbed, it must be disposed of along with any adsorbed pollutants. The capital and operating costs of thermal regeneration are relatively high. Cost surveys show that thermal regeneration is generally economical when carbon usage exceeds about 1,000 lb/day. Carbon cannot remove low molecular weight or highly soluble organics. It also has a low tolerance for suspended solids, which must be removed to at least 50 mg/l in the influent water.

Operational Factors. Reliability: This system should be very reliable with upstream protection and proper operation and maintenance procedures.

Maintainability: This system requires periodic regeneration or replacement of spent carbon and is dependent upon raw waste load and process efficiency.

Solid Waste Aspects: Solid waste from this process is contaminated activated carbon that requires disposal. Carbon undergoes regeneration, reduces the solid waste problem by reducing the frequency of carbon replacement.

Demonstration Status. Carbon adsorption systems have been demonstrated to be practical and economical in reducing COD, BOD and related parameters in secondary municipal and industrial wastewaters; in removing toxic or refractory organics from isolated industrial wastewaters; in removing and recovering certain organics from wastewaters; and in the removing and some times recovering, of selected inorganic chemicals from aqueous wastes. Carbon adsorption is a viable and economic process for organic waste streams containing up to 1 to 5 percent of refractory or toxic organics. Its applicability for removal of inorganics such as metals has also been demonstrated.

9. Centrifugation

Centrifugation is the application of centrifugal force to separate solids and liquids in a liquid-solid mixture or to effect concentration of the solids. The application of centrifugal force is effective because of the density differential normally found between the insoluble solids and the liquid in which they are contained. As a waste treatment procedure, centrifugation is applied to dewatering of sludges. One type of centrifuge is shown in Figure VII-18 (page 293).

There are three common types of centrifuges: the disc, basket, and conveyor type. All three operate by removing solids under the influence of centrifugal force. The fundamental difference between the three types is the method by which solids are collected in and discharged from the bowl.

In the disc centrifuge, the sludge feed is distributed between narrow channels that are present as spaces between stacked conical discs. Suspended particles are collected and discharged continuously through small orifices in the bowl wall. The clarified effluent is discharged through an overflow weir.

A second type of centrifuge which is useful in dewatering sludges is the basket centrifuge. In this type of centrifuge, sludge feed is introduced at the bottom of the basket, and solids collect at the bowl wall while clarified effluent overflows the lip ring at the top. Since the basket centrifuge does not have provision for continuous discharge of collected cake, operation requires interruption of the feed for cake discharge for a minute or two in a 10 to 30 minute overall cycle.

The third type of centrifuge commonly used in sludge dewatering is the conveyor type. Sludge is fed through a stationary feed pipe into a rotating bowl in which the solids are settled out against the bowl wall by centrifugal force. From the bowl wall, they are moved by a screw to the end of the machine, at which point whey are discharged. The liquid effluent is discharged through ports after passing the length of the bowl under centrifugal force.

Application And Performance. Virtually all industrial waste treatment systems producing sludge can use centrifugation to dewater it. Centrifugation is currently being used by a wide range of industrial concerns.

The performance of sludge dewatering by centrifugation depends on the feed rate, the rotational velocity of the drum, and the sludge composition and concentration. Assuming proper design and operation, the solids content of the sludge can be increased to 20-35 percent.

Advantages And Limitations. Sludge dewatering centrifuges have minimal space requirements and show a high degree of effluent clarification. The operation is simple, clean, and relatively inexpensive. The area required for a centrifuge system installation is less than that required for a filter system or sludge drying bed of equal capacity, and the initial cost is lower.

Centrifuges have a high power cost that partially offsets the low initial cost. Special consideration must also be given to providing sturdy foundations and soundproofing because of the vibration and noise that result from centrifuge operation. Adequate electrical power must also be provided since large motors are required. The major difficulty encountered in the operation of centrifuges has been the disposal of the concentrate which is relatively high in suspended, non-settling solids.

Operational Factors. Reliability: Centrifugation is highly reliable with proper control of factors such as sludge feed, consistency, and temperature. Pretreatment such as grit removal and coagulant addition may be necessary, depending on the composition of the sludge and on the type of centrifuge employed.

Maintainability: Maintenance consists of periodic lubrication, cleaning, and inspection. The frequency and degree of inspection required varies depending on the type of sludge solids being dewatered and the maintenance service conditions. If the sludge is abrasive, it is recommended that the first inspection of the rotating assembly be made after approximately 1,000 hours of operation. If the sludge is not abrasive or corrosive, then the initial inspection might be delayed. Centrifuges not equipped with a continuous sludge discharge system require periodic shutdowns for manual sludge cake removal.

Solid Waste Aspects: Sludge dewatered in the centrifugation process may be disposed of by landfill. The clarified effluent (centrate), if high in dissolved or suspended solids, may require further treatment prior to discharge.

Demonstration Status. Centrifugation is currently used in a great many commercial applications to dewater sludge. Work is underway to improve the efficiency, increase the capacity, and lower the costs associated with centrifugation.

10. Coalescing

The basic principle of coalescence involves the preferential wetting of a coalescing medium by oil droplets which accumulate on the medium and then rise to the surface of the solution as they combine to form larger particles. The most important requirements for coalescing media are wettability for oil and large surface area. Monofilament line is sometimes used as a coalescing medium.

Coalescing stages may be integrated with a wide variety of gravity oil separation devices, and some systems may incorporate several coalescing stages. In general a preliminary oil skimming step is desirable to avoid overloading the coalescer.

One commercially marketed system for oily waste treatment combines coalescing with inclined plate separation and filtration. In this system, the oily wastes flow into an inclined plate settler. This unit consists of a stack of inclined baffle plates in a cylindrical container with an oil collection chamber at the top. The oil droplets rise and impinge upon the undersides of the plates. They then migrate upward to a guide rib which directs the oil to the oil collection chamber, from which oil is discharged for reuse or disposal.

The oily water continues on through another cylinder containing replaceable filter cartridges, which remove suspended particles from the waste. From there the wastewater enters a final cylinder in which the coalescing material is housed. As the oily water passes through the many small, irregular, continuous passages in the coalescing material, the oil droplets coalesce and rise to an oil collection chamber.

Application and Performance. Coalescing is used to treat oily wastes which do not separate readily in simple gravity systems. The three stage system described above has achieved effluent concentrations of 10-15 mg/l oil and grease from raw waste concentrations of 1000 mg/l or more.

Advantages and Limitations. Coalescing allows removal of oil droplets too finely dispersed for conventional gravity separation-skimming technology. It also can significantly reduce the residence times (and therefore separator volumes) required to achieve separation of oil from some wastes. Because of its simplicity, coalescing provides generally high reliability and low capital and operating costs. Coalescing is not generally effective in removing soluble or chemically stabilized emulsified oils. To avoid plugging, coalescers must be protected by pretreatment from very high concentrations of free oil and grease and suspended solids. Frequent replacement of prefilters may be necessary when raw waste oil concentrations are high.

Operational Factors. Reliability: Coalescing is inherently highly reliable since there are no moving parts, and the coalescing substrate (monofilament, etc.) is inert in the process and therefore not subject to frequent regeneration or replacement requirements. Large loads or inadequate pretreatment, however, may result in plugging or bypass of coalescing stages.

Maintainability: Maintenance requirements are generally limited to replacement of the coalescing medium on an infrequent basis.

Solid Waste Aspects: No appreciable solid waste is generated by this process.

Demonstration Status. Coalescing has been fully demonstrated in industries generating oily wastewater, although none are currently not in use at any coil coating facility.

11. Cyanide Oxidation By Chlorine

Cyanide oxidation using chlorine is widely used in industrial waste treatment to oxidize cyanide. Chlorine can be utilized in either the elemental or hypochlorite forms. This classic procedure can be illustrated by the following two step chemical reaction:

1. $Cl_2 + NaCN + 2NaOH \rightarrow NaCNO + 2NaCl + H_2O$

2. $3Cl_2 + 6NaOH + 2NaCNO \rightarrow 2NaHCO_3 + N_2 + 6NaCl + 2H_2O$

The reaction presented as equation (2) for the oxidation of cyanate is the final step in the oxidation of cyanide. A complete system for the alkaline chlorination of cyanide is shown in Figure VII-19 (page 294).

The alkaline chlorination process oxidizes cyanides to carbon dioxide and nitrogen. The equipment often consists of an equalization tank followed by two reaction tanks, although the reaction can be carried out in a single tank. Each tank has an electronic recorder-controller to maintain required conditions with respect to pH and oxidation reduction potential (ORP). In the first reaction tank, conditions are adjusted to oxidize cyanides to cyanates. To effect the reaction, chlorine is metered to the reaction tank as required to maintain the ORP in the range of 350 to 400 millivolts, and 50 percent aqueous caustic soda is added to maintain a pH range of 9.5 to 10. In the second reaction tank, conditions are maintained to oxidize cyanate to carbon dioxide and nitrogen. The desirable ORP and pH for this reaction are 600 millivolts and a pH of 8.0. Each of the reaction tanks is equipped with a propeller agitator designed to provide approximately one turnover per minute. Treatment by the batch process is accomplished by using two tanks, one for collection of water over a specified time period, and one tank for the treatment of an accumulated batch. If dumps of concentrated wastes are frequent, another tank may be required to equalize the flow to the treatment tank. When the holding tank is full, the liquid is transferred to the reaction tank for treatment. After treatment, the supernatant is discharged and the sludges are collected for removal and ultimate disposal.

Application and Performance. The oxidation of cyanide waste by chlorine is a classic process and is found in most industrial plants using cyanide. This process is capable of achieving effluent levels that are nondetectable. The process is potentially applicable to coil coating facilities where cyanide is a component in conversion coating formulations.

Advantages and Limitations. Some advantages of chlorine oxidation for handling process effluents are operation at ambient temperature, suitability for automatic control, and low cost. Disadvantages include the need for careful pH control, possible chemical interference in the treatment of mixed wastes, and the potential hazard of storing and handling chlorine gas.

Operational Factors. Reliability: Chlorine oxidation is highly reliable with proper monitoring and control, and proper pretreatment to control interfering substances.

Maintainability: Maintenance consists of periodic removal of sludge and recalibration of instruments.

Solid Waste Aspects: There is no solid waste problem associated with chlorine oxidation.

Demonstration Status. The oxidation of cyanide wastes by chlorine is a widely used process in plants using cyanide in cleaning and metal processing baths.

12. Cyanide Oxidation By Ozone

Ozone is a highly reactive oxidizing agent which is approximately ten times more soluble than oxygen on a weight basis in water. Ozone may be produced by several methods, but the silent electrical discharge method is predominant in the field. The silent electrical discharge process produces ozone by passing oxygen or air between electrodes separated by an insulating material. A complete ozonation system is represented in Figure VII-20 (page 295).

Application and Performance. Ozonation has been applied commercially to oxidize cyanides, phenolic chemicals, and organometal complexes. Its applicability to photographic wastewaters has been studied in the laboratory with good results. Ozone is used in industrial waste treatment primarily to oxidize cyanide to cyanate and to oxidize phenols and dyes to a variety of colorless nontoxic products.

Oxidation of cyanide to cyanate is illustrated below:

$$CN^- + O_3 \rightarrow CNO^- + O_2$$

Continued exposure to ozone will convert the cyanate formed to carbon dioxide and ammonia; however, this is not economically practical.

Ozone oxidation of cyanide to cyanate requires 1.8 to 2.0 pounds ozone per pound of CN-; complete oxidation requires 4.6 to 5.0 pounds ozone per pound of CN-. Zinc, copper, and nickel cyanides are easily destroyed to a nondetectable level, but cobalt and iron cyanides are more resistant to ozone treatment.

Advantages and Limitations. Some advantages of ozone oxidation for handling process effluents are its suitability to automatic control and on-site generation and the fact that reaction products are not chlorinated organics and no dissolved solids are added in the treatment step. Ozone in the presence of activated carbon, ultraviolet, and other promoters shows promise of reducing reaction time and improving ozone utilization, but the process at present is limited by high capital expense, possible chemical interference in the treatment of mixed wastes, and an energy requirement of 25 kwh/kg of ozone generated. Cyanide is not economically oxidized beyond the cyanate form.

Operational Factors. Reliability: Ozone oxidation is highly reliable with proper monitoring and control, and proper pretreatment to control interfering substances.

Maintainability: Maintenance consists of periodic removal of sludge, and periodic renewal of filters and desiccators required for the input of clean dry air; filter life is a function of input concentrations of detrimental constituents.

Solid Waste Aspects: Pretreatment to eliminate substances which will interfere with the process may be necessary. Dewatering of sludge generated in the ozone oxidation process or in an "in line" process may be desirable prior to disposal.

13. Cyanide Oxidation By Ozone With UV Radiation

One of the modifications of the ozonation process is the simultaneous application of ultraviolet light and ozone for the treatment of wastewater, including treatment of halogenated organics. The combined action of these two forms produces reactions by photolysis, photosensitization, hydroxylation, oxygenation and oxidation. The process is unique because several reactions and reaction species are active simultaneously.

Ozonation is facilitated by ultraviolet absorption because both the ozone and the reactant molecules are raised to a higher energy state so that they react more rapidly. In addition, free radicals for use in the reaction are readily hydrolyzed by the water present. The energy and reaction intermediates created by the introduction of both ultraviolet and ozone greatly reduce the amount of ozone required compared with a system using ozone alone. Figure VII-21 (page 296) shows a three-stage UV-ozone system. A system to treat mixed cyanides requires pretreatment that involves chemical coagulation, sedimentation, clarification, equalization, and pH adjustment.

Application and Performance. The ozone-UV radiation process was developed primarily for cyanide treatment in the electroplating and color photo-processing areas. It has been successfully applied to mixed cyanides and organics from organic chemicals manufacturing processes. The process is particularly useful for treatment of complexed cyanides such as ferricyanide, copper cyanide and nickel cyanide, which are resistant to ozone alone.

Ozone combined with UV radiation is a relatively new technology. Four units are currently in operation and all four treat cyanide bearing waste.

Ozone-UV treatment could be used in coil coating plants to destroy cyanide present in waste streams from some conversion coating operations.

14. Cyanide Oxidation By Hydrogen Peroxide

Hydrogen peroxide oxidation removes both cyanide and metals in cyanide containing wastewaters. In this process, cyanide bearing waters are heated to 49 - 54°C (120 - 130°F) and the pH is adjusted to 10.5 - 11.8. Formalin (37 percent formaldehyde) is added while the tank is vigorously agitated. After 2-5 minutes, a proprietary peroxygen compound (41 percent hydrogen peroxide with a catalyst and additives) is added. After an hour of mixing, the reaction is complete. The cyanide is converted to cyanate and the metals are precipitated as oxides or hydroxides. The metals are then removed from solution by either settling or filtration.

The main equipment required for this process is two holding tanks equipped with heaters and air spargers or mechanical stirrers. These tanks may be used in a batch or continuous fashion, with one tank being used for treatment while the other is being filled. A settling tank or a filter is needed to concentrate the precipitate.

Application and Performance. The hydrogen peroxide oxidation process is applicable to cyanidebearing wastewaters, especially those containing metal-cyanide complexes. In terms of waste reduction performance, this process can reduce total cyanide to less than 0.1 mg/l and the zinc or cadmium to less than 1.0 mg/l.

Advantages and Limitations. Chemical costs are similar to those for alkaline chlorination using chlorine and lower than those for treatment with hypochlorite. All free cyanide reacts and is completely oxidized to the less toxic cyanate state. In addition, the metals precipitate and settle quickly, and they may be recoverable in many instances. However, the process requires energy expenditures to heat the wastewater prior to treatment.

Demonstration Status. This treatment process was introduced in 1971 and is used in several facilities. No coil coating plants use oxidation by hydrogen peroxide.

15. Evaporation

Evaporation is a concentration process. Water is evaporated from a solution, increasing the concentration of solute in the remaining solution. If the resulting water vapor is condensed back to liquid water, the evaporation-condensation process is called distillation. However, to be consistent with industry terminology, evaporation is used in this report to describe both processes. Both atmospheric and vacuum evaporation are commonly used in industry today. Specific evaporation techniques are shown in Figure VII-22 (page 297) and discussed below.

Atmospheric evaporation could be accomplished simply by boiling the liquid. However, to aid evaporation, heated liquid is sprayed on an evaporation surface, and air is blown over the surface and subsequently released to the atmosphere. Thus, evaporation occurs by humidification of the air stream, similar to a drying process. Equipment for carrying out atmospheric evaporation is quite similar for most applications. The major element is generally a packed column with an accumulator bottom. Accumulated wastewater is pumped from the base of the column, through a heat exchanger, and back into the top of the column, where it is sprayed into the packing. At the same time, air drawn upward through the packing by a fan is heated as it contacts the hot liquid. The liquid partially vaporizes and humidifies the air stream. The fan then blows the hot, humid air to the outside atmosphere. A scrubber is often unnecessary because the packed column itself acts as a scrubber.

Another form of atmospheric evaporator also works on the air humidification principle, but the evaporated water is recovered for reuse by condensation. These air humidification techniques operate well below the boiling point of water and can utilize waste process heat to supply the energy required.

In vacuum evaporation, the evaporation pressure is lowered to cause the liquid to boil at reduced temperature. All of the water vapor is condensed and, to maintain the vacuum condition, noncondensible gases (air in particular) are removed by a vacuum pump. Vacuum evaporation may be either single or double effect. In double effect evaporation, two evaporators are used, and the water vapor from the first evaporator (which may be heated by steam) is used to supply heat to the second evaporator. As it supplies heat, the water vapor from the first evaporator condenses. Approximately equal quantities of wastewater are evaporated in each unit; thus, the double effect system evaporates twice the amount of water that a single effect system does, at nearly the same cost in energy but with added capital cost and complexity. The double effect technique is thermodynamically possible because the second evaporator is maintained at lower pressure (higher vacuum) and, therefore, lower evaporation temperature. Another means of increasing energy efficiency is vapor recompression (thermal or mechanical), which enables heat to be transferred from the condensing water vapor to the evaporating wastewater. Vacuum evaporation equipment may be classified as submerged tube or climbing film evaporation units.

In the most commonly used submerged tube evaporator, the heating and condensing coil are contained in a single vessel to reduce capital cost. The vacuum in the vessel is maintained by an eductor-type pump, which creates the required vacuum by the flow of the condenser cooling water through a venturi. Waste water accumulates in the bottom of the vessel, and it is evaporated by means of submerged steam coils. The resulting water vapor condenses as it contacts the condensing coils in the top of the vessel. The condensate then drips off the condensing coils into a collection trough that carries it out of the vessel. Concentrate is removed from the bottom of the vessel.

The major elements of the climbing film evaporator are the evaporator, separator, condenser, and vacuum pump. Waste water is "drawn" into the system by the vacuum so that a constant liquid level is maintained in the separator. Liquid enters the steam-jacketed evaporator tubes, and part of it evaporates so that a mixture of vapor and liquid enters the separator. The design of the separator is such that the liquid is continuously circulated from the separator to the evaporator. The vapor entering the separator flows out through a mesh entrainment separator to the condenser, where it is condensed as it flows down through the condenser tubes. The condensate, along with any entrained air, is pumped out of the bottom of the condenser by a liquid ring vacuum pump. The liquid seal provided by the condensate keeps the vacuum in the system from being broken.

Application and Performance. Both atmospheric and vacuum evaporation are used in many industrial plants, mainly for the concentration and recovery of process solutions. Many of these evaporators also recover water for rinsing. Evaporation has also been applied to recovery of phosphate metal cleaning solutions.

In theory, evaporation should yield a concentrate and a deionized condensate. Actually, carry-over has resulted in condensate metal concentrations as high as 10 mg/l, although the usual level is less than 3 mg/l, pure enough for most final rinses. The condensate may also contain organic brighteners and antifoaming agents. These can be removed with an activated carbon bed, if necessary. Samples from one plant showed 1,900 mg/l zinc in the feed, 4,570 mg/l in the concentrate, and 0.4 mg/l in the condensate. Another plant had 416 mg/l copper in the feed and 21,800 mg/l in the concentrate. Chromium analysis for that plant indicated 5,060 mg/l in the feed and 27,500 mg/l in the concentrate. Evaporators are available in a range of capacities, typically from 15 to 75 gph, and may be used in parallel arrangements for processing of higher flow rates.

Advantages and Limitations. Advantages of the evaporation process are that it permits recovery of a wide variety of process chemicals, and it is often applicable to concentration or removal of compounds which cannot be accomplished by any other means. The major disadvantage is that the evaporation process consumes relatively large amounts of energy for the evaporation of water. However, the recovery of waste heat from many industrial processes (e.g., diesel generators, incinerators, boilers and furnaces) should be considered as a source of this heat for a totally integrated evaporation system. Also, in some cases solar heating could be inexpensively and effectively applied to evaporation units. For some applications, pretreatment may be required to remove solids or bacteria which tend to cause fouling in the condenser or evaporator. The buildup of scale on the evaporator surfaces reduces the heat transfer efficiency and may present a maintenance problem or increase operating cost. However, it has been demonstrated that fouling of the heat transfer surfaces can be avoided or minimized for certain dissolved solids by maintaining a seed slurry which provides preferential sites for precipitate deposition. In addition, low temperature differences in the evaporator will eliminate nucleate boiling and supersaturation effects. Steam distillable impurities in the process stream are carried over with the product water and must be handled by pre or post treatment.

Operational Factors. Reliability: Proper maintenance will ensure a high degree of reliability for the system. Without such attention, rapid fouling or deterioration of vacuum seals may occur, especially when handling corrosive liquids.

Maintainability: Operating parameters can be automatically controlled. Pretreatment may be required, as well as periodic cleaning of the system. Regular replacement of seals, especially in a corrosive environment, may be necessary.

Solid Waste Aspects: With only a few exceptions, the process does not generate appreciable quantities of solid waste.

Demonstration Status. Evaporation is a fully developed, commercially available wastewater treatment system. It is used extensively to recover plating chemicals in the electroplating industry and a pilot scale unit has been used in connection with phosphating of aluminum. Proven performance in silver recovery indicates that evaporation could be a useful treatment operation for the photographic industry, as well as for metal finishing. No data have been reported showing the use of evaporation in coil coating plants.

16. Flotation

Flotation is the process of causing particles such as metal hydroxides or oil to float to the surface of a tank where they can be concentrated and removed. This is accomplished by releasing gas bubbles which attach to the solid particles, increasing their buoyancy and causing them to float. In principle, this process is the opposite of sedimentation. Figure VII-23 (page 298) shows one type of flotation system.

Flotation is used primarily in the treatment of wastewater streams that carry heavy loads of finely divided suspended solids or oil. Solids having a specific gravity only slightly greater than 1.0, which would require abnormally long sedimentation times, may be removed in much less time by flotation.

This process may be performed in several ways: foam, dispersed air, dissolved air, gravity, and vacuum flotation are the most commonly used techniques. Chemical additives are often used to enhance the performance of the flotation process.

The principal difference among types of flotation is the method of generating the minute gas bubbles (usually air) in a suspension of water and small particles. Chemicals may be used to improve the efficiency with any of the basic methods. The following paragraphs describe the different flotation techniques and the method of bubble generation for each process.

Froth Flotation - Froth flotation is based on differences in the physiochemical properties in various particles. Wettability and surface properties affect the particles' ability to attach themselves to gas bubbles in an aqueous medium. In froth flotation, air is blown through the solution containing flotation reagents. The particles with water repellant surfaces stick to air bubbles as they rise and are brought to the surface. A mineralized froth layer, with mineral particles attached to air bubbles, is formed. Particles of other minerals which are readily wetted by water do not stick to air bubbles and remain in suspension.

Dispersed Air Flotation - In dispersed air flotation, gas bubbles are generated by introducing the air by means of mechanical agitation with impellers or by forcing air through porous media. Dispersed air flotation is used mainly in the metallurgical industry.

Dissolved Air Flotation - In dissolved air flotation, bubbles are produced by releasing air from a supersaturated solution under relatively high pressure. There are two types of contact between the gas bubbles and particles. The first type is predominant in the flotation of flocculated materials and involves the entrapment of rising gas bubbles in the flocculated particles as they increase in size. The bond between the bubble and particle is one of physical capture only. The second type of contact is one of adhesion. Adhesion results from the intermolecular attraction exerted at the interface between the solid particle and gaseous bubble.

Vacuum Flotation - This process consists of saturating the waste water with air either directly in an aeration tank, or by permitting air to enter on the suction of a wastewater pump. A partial vacuum is applied, which causes the dissolved air to come out of solution as minute bubbles. The bubbles attach to solid particles and rise to the surface to form a scum blanket, which is normally removed by a skimming mechanism. Grit and other heavy solids that settle to the bottom are generally raked to a central sludge pump for removal. A typical vacuum flotation unit consists of a covered cylindrical tank in which a partial vacuum is maintained. The tank is equipped with scum and sludge removal mechanisms. The floating material is continuously swept to the tank periphery, automatically discharged into a scum trough, and removed from the unit by a pump also under partial vacuum.

Auxilliary equipment includes an aeration tank for saturating the wastewater with air, a tank with a short retention time for removal of large bubbles, vacuum pumps, and sludge pumps.

Application and Performance. The primary variables for flotation design are pressure, feed solids concentration, and retention period. The suspended solids in the effluent decrease, and the concentration of solids in the float increases with increasing retention period. When the flotation process is used primarily for clarification, a retention period of 20 to 30 minutes is adequate for separation and concentration.

Advantages and Limitations. Some advantages of the flotation process are the high levels of solids separation achieved in many applications, the relatively low energy requirements, and the adaptability to meet the treatment requirements of different waste types. Limitations of flotation are that it often requires addition of chemicals to enhance process performance and that it generates large quantities of solid waste.

Operational Factors. Reliability: Flotation systems normally are very reliable with proper maintenance of the sludge collector mechanism and the motors and pumps used for aeration.

Maintainability: Routine maintenance is required on the pumps and motors. The sludge collector mechanism is subject to possible corrosion or breakage and may require periodic replacement.

Solid Waste Aspects: Chemicals are commonly used to aid the flotation process by creating a surface or a structure that can easily adsorb or entrap air bubbles. Inorganic chemicals, such as the aluminum and ferric salts, and activated silica, can bind the particulate matter together and create a structure that can entrap air bubbles. Various organic chemicals can change the nature of either the air-liquid interface or the solid-liquid interface, or both. These compounds usually collect on the interface to bring about the desired changes. The added chemicals plus the particles in solution combine to form a large volume of sludge which must be further treated or properly disposed.

Demonstration Status. Flotation is a fully developed process and is readily available for the treatment of a wide variety of industrial waste streams.

17. Gravity Sludge Thickening

In the gravity thickening process, dilute sludge is fed from a primary settling tank or clarifier to a thickening tank where rakes stir the sludge gently to densify it and to push it to a central collection well. The supernatant is returned to the primary settling tank. The thickened sludge that collects on the bottom of the tank is pumped to dewatering equipment or hauled away. Figure VII-24 (page 299) shows the construction of a gravity thickener.

Application and Performance. Thickeners are generally used in facilities where the sludge is to be further dewatered by a compact mechanical device such as a vacuum filter or centrifuge. Doubling the solids content in the thickener substantially reduces capital and operating cost of the subsequent dewatering device and also reduces cost for hauling. The process is potentially applicable to almost any industrial plant.

Organic sludges from sedimentation units of one to two percent solids concentration can usually be gravity thickened to six to ten percent; chemical sludges can be thickened to four to six percent.

Advantages and Limitations. The principal advantage of a gravity sludge thickening process is that it facilitates further sludge dewatering. Other advantages are high reliability and minimum maintenance requirements.

Limitations of the sludge thickening process are its sensitivity to the flow rate through the thickener and the sludge removal rate. These rates must be low enough not to disturb the thickened sludge.

Operational Factors. Reliability: Reliability is high with proper design and operation. A gravity thickener is designed on the basis of square feet per pound of solids per day, in which the required surface area is related to the solids entering and leaving the unit. Thickener area requirements are also expressed in terms of mass loading, grams of solids per square meter per day (lbs/sq ft/day).

Maintainability: Twice a year, a thickener must be shut down for lubrication of the drive mechanisms. Occasionally, water must be pumped back through the system in order to clear sludge pipes.

Solid Waste Aspects: Thickened sludge from a gravity thickening process will usually require further dewatering prior to disposal, incineration, or drying. The clear effluent may be recirculated in part, or it may be subjected to further treatment prior to discharge.

Demonstration Status. Gravity sludge thickeners are used throughout industry to reduce water content to a level where the sludge may be efficiently handled. Further dewatering is usually practiced to minimize costs of hauling the sludge to approved landfill areas. Sludge thickening is used in seven coil coating plants.

18. Insoluble Starch Xanthate

Insoluble starch xanthate is essentially an ion exchange medium used to remove dissolved heavy metals from wastewater. The water may then either be reused (recovery application) or discharged (end-of-pipe application). In a commercial electroplating operation, starch xanthate is coated on a filter medium. Rinse water containing dragged out heavy metals is circulated through the filters and then reused for rinsing. The starch-heavy metal complex is disposed of and replaced periodically. Laboratory tests indicate that recovery of metals from the complex is feasible, with regeneration of the starch xanthate. Besides electroplating, starch xanthate is potentially applicable to coil coating, porcelain·enameling, copper fabrication, and any other industrial plants where dilute metal wastewater streams are generated. Its present use is limited to one electroplating plant.

19. Ion Exchange

Ion exchange is a process in which ions, held by electrostatic forces to charged functional groups on the surface of the ion exchange resin, are exchanged for ions of similar charge from the solution in which the resin is immersed. This is classified as a sorption process because the exchange occurs on the surface of the resin, and the exchanging ion must undergo a phase transfer from solution phase to solid phase. Thus, ionic contaminants in a waste stream can be exchanged for the harmless ions of the resin.

Although the precise technique may vary slightly according to the application involved, a generalized process description follows. The wastewater stream being treated passes through a filter to remove any solids, then flows through a cation exchanger which contains the ion exchange resin. Here, metallic impurities such as copper, iron, and trivalent chromium are retained. The stream then passes through the anion exchanger and its associated resin. Hexavalent chromium, for example, is retained in this stage. If one pass does not reduce the contaminant levels sufficiently, the stream may then enter another series of exchangers. Many ion exchange systems are equipped with more than one set of exchangers for this reason.

The other major portion of the ion exchange process concerns the regeneration of the resin, which now holds those impurities retained from the waste stream. An ion exchange unit with in-place regeneration is shown in Figure VII-25 (page 300). Metal ions such as nickel are removed by an acid, cation exchange resin, which is regenerated with hydrochloric or sulfuric acid, replacing the metal ion with one or more hydrogen ions. Anions such as dichromate are removed by a basic, anion exchange resin, which is regenerated with sodium hydroxide, replacing the anion with one or more hydroxyl ions. The three principal methods employed by industry for regenerating the spent resin are:

A) Replacement Service: A regeneration service replaces the spent resin with regenerated resin, and regenerates the spent resin at its own facility. The service then has the problem of treating and disposing of the spent regenerant.

B) In-Place Regeneration: Some establishments may find it less expensive to do their own regeneration. The spent resin column is shut down for perhaps an hour, and the spent resin is regenerated. This results in one or more waste streams which must be treated in an appropriate manner. Regeneration is performed as the resins require it, usually every few months.

C) Cyclic Regeneration: In this process, the regeneration of the spent resins takes place within the ion exchange unit itself in alternating cycles with the ion removal process. A regeneration frequency of twice an hour is typical. This very short cycle time permits operation with a very small quantity of resin and with fairly concentrated solutions, resulting in a very compact system. Again, this process varies according to application, but the regeneration cycle generally begins with caustic being pumped through the anion exchanger, carrying out hexavalent chromium, for example, as sodium dichromate. The sodium dichromate stream then passes through a cation exchanger, converting the sodium dichromate to chromic acid. After concentration by evaporation or other means, the chromic acid can be returned to the process line. Meanwhile, the cation exchanger is regenerated with sulfuric acid, resulting in a waste acid stream containing the metallic impurities removed earlier. Flushing the exchangers with water completes the cycle. Thus, the wastewater is purified and, in this example, chromic acid is recovered. The ion exchangers, with newly regenerated resin, then enter the ion removal cycle again.

Application and Performance. The list of pollutants for which the ion exchange system has proven effective includes aluminum, arsenic, cadmium, chromium (hexavalent and trivalent), copper, cyanide, gold, iron, lead, manganese, nickel, selenium, silver, tin, zinc, and more. Thus, it can be applied to a wide variety of industrial concerns. Because of the heavy concentrations of metals in their wastewater, the metal finishing industries utilize ion exchange in several ways. As an end-of-pipe treatment, ion exchange is certainly feasible, but its greatest value is in recovery applications. It is commonly used as an integrated treatment to recover rinse water and process chemicals. Some electroplating facilities use ion exchange to concentrate and purify plating baths. Also, many industrial concerns, including a number of coil coating plants, use ion exchange to reduce salt concentrations in incoming water sources.

Ion exchange is highly efficient at recovering metal bearing solutions. Recovery of chromium, nickel, phosphate solution, and sulfuric acid from anodizing is commercial. A chromic acid recovery efficiency of 99.5 percent has been demonstrated. Typical data for purification of rinse water have been reported and are displayed in Table VII-24 (page 274).

Ion exchange is a versatile technology applicable to a great many situations. This flexibility, along with its compact nature and performance, makes ion exchange a very effective method of waste water treatment. However, the resins in these systems can prove to be a limiting factor. The thermal limits of the anion resins, generally in the vicinity of 60°C, could prevent its use in certain situations. Similarly, nitric acid, chromic acid, and hydrogen peroxide can all damage the resins, as will iron, manganese, and copper when present with sufficient concentrations of dissolved oxygen. Removal of a particular trace contaminant may be uneconomical because of the presence of other ionic species that are preferentially removed. The regeneration of the resins presents its own problems. The cost of the regenerative chemicals can be high. In addition, the waste streams originating from the regeneration process are extremely high in pollutant concentrations, although low in volume. These must be further processed for proper disposal.

Operational Factors. Reliability: With the exception of occasional clogging or fouling of the resins, ion exchange has proved to be a highly dependable technology.

Maintainability: Only the normal maintenance of pumps, valves, piping and other hardware used in the regeneration process is required.

Solid Waste Aspects: Few, if any, solids accumulate within the ion exchangers, and those which do appear are removed by the regeneration process. Proper prior treatment and planning can eliminate solid buildup problems altogether. The brine resulting from regeneration of the ion exchange resin most usually must be treated to remove metals before discharge. This can generate solid waste.

Demonstration Status. All of the applications mentioned in this document are available for commercial use, and industry sources estimate the number of units currently in the field at well over 120. The research and development in ion exchange is focusing on improving the quality and efficiency of the resins, rather than new applications. Work is also being done on a continuous regeneration process whereby the resins are contained on a fluid-transfusible belt. The belt passes through a compartmented tank with ion exchange, washing, and regeneration sections. The resins are therefore continually used and regenerated. No such system, however, has been reported beyond the pilot stage.

20. Membrane Filtration

Membrane filtration is a treatment system for removing precipitated metals from a wastewater stream. It must therefore be preceded by those treatment techniques which will properly prepare the wastewater for solids removal. Typically, a membrane filtration unit is preceded by pH adjustment or sulfide addition for precipitation of the metals. These steps are followed by the addition of a proprietary chemical reagent which causes the precipitate to be non-gelatinous, easily dewatered, and highly stable. The resulting mixture of pretreated wastewater and reagent is continuously recirculated through a filter module and back into a recirculation tank. The filter module contains tubular membranes. While the reagent-metal hydroxide precipitate mixture flows through the inside of the tubes, the water and any dissolved salts permeate the membrane. When the recirculating slurry reaches a concentration of 10 to 15 percent solids, it is pumped out of the system as sludge.

Application and Performance. Membrane filtration appears to be applicable to any wastewater or process water containing metal ions which can be precipitated using hydroxide, sulfide or carbonate precipitation. It could function as the primary treatment system, but also might find application as a polishing treatment (after precipitation and settling) to ensure continued compliance with metals limitations. Membrane filtration systems are being used in a number of industrial applications, particularly in the metal finishing area. They have also been used for heavy metals removal in the metal fabrication industry and the paper industry.

The permeate is claimed by one manufacturer to contain less than the effluent concentrations shown in the following table, regardless of the influent concentrations. These claims have been largely substantiated by the analysis of water samples at various plants in various industries.

In the performance predictions for this technology, pollutant concentrations are reduced to the levels shown in Table VII-25 (page 274) unless lower levels are present in the influent stream.

A major advantage of the membrane filtration system is that installations can use most of the conventional end-of-pipe systems that may already be in place. Removal efficiencies are claimed to be excellent, even with sudden variation of pollutant input rates; however, the effectiveness of the membrane filtration system can be limited by clogging of the filters. Because pH changes in the waste stream greatly intensify clogging problems, the pH must be carefully monitored and controlled. Clogging can force the shutdown of the system and may interfere with production. In addition, relatively high capital cost of this system may limit its use.

Operational Factors. Reliability: Membrane filtration has been shown to be a very reliable system, provided that the pH is strictly controlled. Improper pH can result in the clogging of the membrane. Also, surges in the flow rate of the waste stream must be controlled in order to prevent solids from passing through the filter and into the effluent.

Maintainability: The membrane filters must be regularly monitored, and cleaned or replaced as necessary. Depending on the composition of the waste stream and its flow rate, frequent cleaning of the filters may be required. Flushing with hydrochloric acid for 6-24 hours will usually suffice. In addition, the routine maintenance of pumps, valves, and other plumbing is required.

Solid Waste Aspects: When the recirculating reagent-precipitate slurry reaches 10 to 15 percent solids, it is pumped out of the system. It can then be disposed of directly or it can undergo a dewatering process. Because this sludge contains toxic metals, it requires proper disposal.

Demonstration Status. There are more than 25 membrane filtration systems presently in use on metal finishing and similar wastewaters. Bench scale and pilot studies are being run in an attempt to expand the list of pollutants for which this system is known to be effective. Although there are no data on the use of membrane filtration in coil coating plants, the concept has been successfully demonstrated using coil coating plant wastewater. A unit has been installed at one coil coating plant based on these tests.

21. Peat Adsorption

Peat moss is a complex natural organic material containing lignin and cellulose as major constituents. These constituents, particularly lignin, bear polar functional groups, such as alcohols, aldehydes, ketones, acids, phenolic hydroxides, and ethers, that can be involved in chemical bonding. Because of the polar nature of the material, its adsorption of dissolved solids such as transition metals and polar organic molecules is quite high. These properties have led to the use of peat as an agent for the purification of industrial wastewater.

Peat adsorption is a "polishing" process which can achieve very low effluent concentrations for several pollutants. If the concentrations of pollutants are above 10 mg/l, then peat adsorption must be preceded by pH adjustment for metals precipitation and subsequent clarification. Pretreatment is also required for chromium wastes using ferric chloride and sodium sulfide. The wastewater is then pumped into a large metal chamber called a kier which contains a layer of peat through which the waste stream passes. The water flows to a second kier for further adsorption. The wastewater is then ready for discharge. This system may be automated or manually operated.

Application and Performance. Peat adsorption can be used in coil coating for removal of residual dissolved metals from clarifier effluent. Peat moss may be used to treat wastewaters containing heavy metals such as mercury, cadmium, zinc, copper, iron, nickel, chromium, and lead, as well as organic matter such as oil, detergents, and dyes. Peat adsorption is currently used commercially at a textile plant, a newsprint facility, and a metal reclamation operation.

Table VII-27 (page 275) contains performance figures obtained from pilot plant studies. Peat adsorption was preceded by pH adjustment for precipitation and by clarification.

In addition, pilot plant studies have shown that chelated metal wastes, as well as the chelating agents themselves, are removed by contact with peat moss.

Advantages and Limitations. The major advantages of the system include its ability to yield low pollutant concentrations, its broad scope in terms of the pollutants eliminated, and its capacity to accept wide variations of waste water composition.

Limitations include the cost of purchasing, storing, and disposing of the peat moss; the necessity for regular replacement of the peat may lead to high operation and maintenance costs. Also, the pH adjustment must be altered according to the composition of the waste stream.

Operational Factors. Reliability: The question of long term reliability is not yet fully answered. Although the manufacturer reports it to be a highly reliable system, operating experience is needed to verify the claim.

Maintainability: The peat moss used in this process soon exhausts its capacity to adsorb pollutants. At that time, the kiers must be opened, the peat removed, and fresh peat placed inside. Although this procedure is easily and quickly accomplished, it must be done at regular intervals, or the system's efficiency drops drastically.

Solid Waste Aspects: After removal from the kier, the spent peat must be eliminated. If incineration is used, precautions should be taken to insure that those pollutants removed from the water are not released again in the combustion process. Presence of sulfides in the spent peat, for example, will give rise to sulfur dioxide in the fumes from burning. The presence of significant quantities of toxic heavy metals in coil coating manufacturing wastewater will in general preclude incineration of peat used in treating these wastes.

Demonstration Status. Only three facilities currently use commercial adsorption systems in the United States - a textile manufacturer, a newsprint facility, and a metal reclamation firm. No data have been reported showing the use of peat adsorption in coil coating plants.

22. Reverse Osmosis

The process of osmosis involves the passage of a liquid through a semipermeable membrane from a dilute to a more concentrated solution. Reverse osmosis (RO) is an operation in which pressure is applied to the more concentrated solution, forcing the permeate to diffuse through the membrane and into the more dilute solution. This filtering action produces a concentrate and a permeate on opposite sides of the membrane. The concentrate can then be further treated or returned to the original operation for continued use, while the permeate water can be recycled for use as clean water. Figure VII-26 (page 301) depicts a reverse osmosis system.

As illustrated in Figure VII-27 (page 302), there are three basic configurations used in commercially available RO modules: tubular, spiral-wound, and hollow fiber. All of these operate on the principle described above, the major difference being their mechanical and structural design characteristics.

The tubular membrane module uses a porous tube with a cellulose acetate membrane-lining. A common tubular module consists of a length of 2.5 cm (1 inch) diameter tube wound on a supporting spool and encased in a plastic shroud. Feed water is driven into the tube under pressures varying from 40 - 55 atm (600-800 psi). The permeate passes through the walls of the tube and is collected in a manifold while the concentrate is drained off at the end of the tube. A less widely used tubular RO module uses a straight tube contained in a housing, under the same operating conditions.

Spiral-wound membranes consist of a porous backing sandwiched between two cellulose acetate membrane sheets and bonded along three edges. The fourth edge of the composite sheet is attached to a large permeate collector tube. A spacer screen is then placed on top of the membrane sandwich and the entire stack is rolled around the centrally located tubular permeate collector. The rolled up package is inserted into a pipe able to withstand the high operating pressures employed in this process, up to 55 atm (800 psi) with the spiral-wound module. When the system is operating, the pressurized product water permeates the membrane and flows through the backing material to the central collector tube. The concentrate is drained off at the end of the container pipe and can be reprocessed or sent to further treatment facilities.

The hollow fiber membrane configuration is made up of a bundle of polyamide fibers of approximately 0.0075 cm (0.003 in.) OD and 0.0043 cm (0.0017 in.) ID. A commonly used hollow fiber module contains several hundred thousand of the fibers placed in a long tube, wrapped around a flow screen, and rolled into a spiral.

The fibers are bent in a U-shape and their ends are supported by an epoxy bond. The hollow fiber unit is operated under 27 atm (400 psi), the feed water being dispersed from the center of the module through a porous distributor tube. Permeate flows through the membrane to the hollow interiors of the fibers and is collected at the ends of the fibers.

The hollow fiber and spiral-wound modules have a distinct advantage over the tubular system in that they are able to load a very large membrane surface area into a relatively small volume. However, these two membrane types are much more susceptible to fouling than the tubular system, which has a larger flow channel. This characteristic also makes the tubular membrane much easier to clean and regenerate than either the spiral-wound or hollow fiber modules. One manufacturer claims that their helical tubular module can be physically wiped clean by passing a soft porous polyurethane plug under pressure through the module.

Application and Performance. In a number of metal processing plants, the overflow from the first rinse in a countercurrent setup is directed to a reverse osmosis unit, where it is separated into two streams. The concentrated stream contains dragged out chemicals and is returned to the bath to replace the loss of solution due to evaporation and dragout. The dilute stream (the permeate) is routed to the last rinse tank to provide water for the rinsing operation. The rinse flows from the last tank to the first tank and the cycle is complete.

The closed-loop system described above may be supplemented by the addition of a vacuum evaporator after the RO unit in order to further reduce the volume of reverse osmosis concentrate. The evaporated vapor can be condensed and returned to the last rinse tank or sent on for further treatment.

The largest application has been for the recovery of nickel solutions. It has been shown that RO can generally be applied to most acid metal baths with a high degree of performance, providing that the membrane unit is not overtaxed. The limitations most critical here are the allowable pH range and maximum operating pressure for each particular configuration. Adequate prefiltration is also essential. Only three membrane types are readily available in commercial RO units, and their overwhelming use has been for the recovery of various acid metal baths. For the purpose of calculating performance predictions of this technology, a rejection ratio of 98 percent is assumed for dissolved salts, with 95 percent permeate recovery.

Advantages and Limitations. The major advantage of reverse osmosis for handling process effluents is its ability to concentrate dilute solutions for recovery of salts and chemicals with low power requirements. No latent heat of vaporization or fusion is required for effecting separations; the main energy requirement is for a high pressure pump. It requires relatively little floor space for compact, high capacity units, and it exhibits good recovery and rejection rates for a number of typical process solutions. A limitation of the reverse osmosis process for treatment of process effluents is its limited temperature range for satisfactory operation. For cellulose acetate systems, the preferred limits are 18° to 30°C (65° to 85°F); higher temperatures will increase the rate of membrane hydrolysis and reduce system life, while lower temperatures will result in decreased fluxes with no damage to the membrane. Another limitation is inability to handle certain solutions. Strong oxidizing agents, strongly acidic or basic solutions, solvents, and other organic compounds can cause dissolution of the membrane. Poor rejection of some compounds such as borates and low molecular weight organics is another problem. Fouling of membranes by slightly soluble components in solution or colloids has caused failures, and fouling of membranes by feed waters with high levels of suspended solids can be a problem. A final limitation is inability to treat or achieve high concentration with some solutions. Some concentrated solutions may have initial osmotic pressures which are so high that they either exceed available operating pressures or are uneconomical to treat.

Operational Factors. Reliability: Very good reliability is achieved so long as the proper precautions are taken to minimize the chances of fouling or degrading the membrane. Sufficient testing of the waste stream prior to application of an RO system will provide the information needed to insure a successful application.

Maintainability: Membrane life is estimated to range from six months to three years, depending on the use of the system. Down time for flushing or cleaning is on the order of 2 hours as often as once each week; a substantial portion of maintenance time must be spent on cleaning any prefilters installed ahead of the reverse osmosis unit.

Solid Waste Aspects: In a closed loop system utilizing RO there is a constant recycle of concentrate and a minimal amount of solid waste. Prefiltration eliminates many solids before they reach the module and helps keep the buildup to a minimum. These solids require proper disposal.

Demonstration Status. There are presently at least one hundred reverse osmosis waste water applications in a variety of industries. In addition to these, there are thirty to forty units being used to provide pure process water for several industries. Despite the many types and configurations of membranes, only the spiral-wound cellulose acetate membrane has had widespread success in commercial applications.

23. Sludge Bed Drying

As a waste treatment procedure, sludge bed drying is employed to reduce the water content of a variety of sludges to the point where they are amenable to mechanical collection and removal to landfill. These beds usually consist of 15 to 45 cm (6 to 18 in.) of sand over a 30 cm (12 in.) deep gravel drain system made up of 3 to 6 mm (1/8 to 1/4 in.) graded gravel overlying drain tiles. Figure VII-28 (page 303) shows the construction of a drying bed.

Drying beds are usually divided into sectional areas approximately 7.5 meters (25 ft) wide x 30 to 60 meters (100 to 200 ft) long. The partitions may be earth embankments, but more often are made of planks and supporting grooved posts.

To apply liquid sludge to the sand bed, a closed conduit or a pressure pipeline with valved outlets at each sand bed section is often employed. Another method of application is by means of an open channel with appropriately placed side openings which are controlled by slide gates. With either type of delivery system, a concrete splash slab should be provided to receive the falling sludge and prevent erosion of the sand surface.

Where it is necessary to dewater sludge continuously throughout the year regardless of the weather, sludge beds may be covered with a fiberglass reinforced plastic or other roof. Covered drying beds permit a greater volume of sludge drying per year in most climates because of the protection afforded from rain or snow and because of more efficient control of temperature. Depending on the climate, a combination of open and enclosed beds will provide maximum utilization of the sludge bed drying facilities.

Application and Performance. Sludge drying beds are a means of dewatering sludge from clarifiers and thickeners. They are widely used both in municipal and industrial treatment facilities.

Dewatering of sludge on sand beds occurs by two mechanisms: filtration of water through the bed and evaporation of water as a result of radiation and convection. Filtration is generally complete in one to two days and may result in solids concentrations as high as 15 to 20 percent. The rate of filtration depends on the drainability of the sludge.

The rate of air drying of sludge is related to temperature, relative humidity, and air velocity. Evaporation will proceed at a constant rate to a critical moisture content, then at a falling rate to an equilibrium moisture content. The average evaporation rate for a sludge is about 75 percent of that from a free water surface.

Advantages and Limitations. The main advantage of sludge drying beds over other types of sludge dewatering is the relatively low cost of construction, operation, and maintenance.

Its disadvantages are the large area of land required and long drying times that depend, to a great extent, on climate and weather.

Operational Factors. Reliability: Reliability is high with favorable climactic conditions, proper bed design and care to avoid excessive or unequal sludge application. If climatic conditions in a given area are not favorable for adequate drying, a cover may be necessary.

Maintainability: Maintenance consists basically of periodic removal of the dried sludge. Sand removed from the drying bed with the sludge must be replaced and the sand layer resurfaced.

The resurfacing of sludge beds is the major expense item in sludge bed maintenance, but there are other areas which may require attention. Underdrains occasionally become clogged and have to be cleaned. Valves or sludge gates that control the flow of sludge to the beds must be kept watertight. Provision for drainage of lines in winter should be provided to prevent damage from freezing. The partitions between beds should be tight so that sludge will not flow from one compartment to another. The outer walls or banks around the beds should also be watertight.

Solid Waste Aspects: The full sludge drying bed must either be abandoned or the collected solids must be removed to a landfill. These solids contain whatever metals or other materials were settled in the clarifier. Metals will be present as hydroxides, oxides, sulfides, or other salts. They have the potential for leaching and contaminating ground water, whatever the location of the semidried solids. Thus the abandoned bed or landfill should include provision for runoff control and leachate monitoring.

Demonstration Status. Sludge beds have been in common use in both municipal and industrial facilities for many years. However, protection of ground water from contamination is not always adequate.

24. Ultrafiltration

Ultrafiltration (UF) is a process which uses semipermeable polymeric membranes to separate emulsified or colloidal materials suspended in a liquid phase by pressurizing the liquid so that it permeates the membrane. The membrane of an ultrafilter forms a molecular screen which retains molecular particles based on their differences in size, shape, and chemical structure. The membrane permits passage of solvents and lower molecular weight molecules. At present, an ultrafilter is capable of removing materials with molecular weights in the range of 1,000 to 100,000 and particles of comparable or larger sizes.

In an ultrafiltration process, the feed solution is pumped through a tubular membrane unit. Water and some low molecular weight materials pass through the membrane under the applied pressure of 10 to 100 psig. Emulsified oil droplets and suspended particles are retained, concentrated, and removed continuously. In contrast to ordinary filtration, retained materials are washed off the membrane filter rather than held by it. Figure VII-29 (page 304) represents the ultrafiltration process.

Application and Performance. Ultrafiltration has potential application to coil coating plants for separation of oils and residual solids from a variety of waste streams. In treating coil coating wastewater its greatest applicability would be as a polishing treatment to remove residual precipitated metals after chemical precipitation and clarification. Successful commercial use, however, has been primarily for separation of emulsified oils from wastewater. Over one hundred such units now operate in the United States, treating emulsified oils from a variety of industrial processes. Capacities of currently operating units range from a few hundred gallons a week to 50,000 gallons per day. Concentration of oily emulsions to 60 percent oil or more are possible. Oil concentrates of 40 percent or more are generally suitable for incineration, and the permeate can be treated further and in some cases recycled back to the process. In this way, it is possible to eliminate contractor removal costs for oil from some oily waste streams.

The following test data indicate ultrafiltration performance (note that UF is not intended to remove dissolved solids):

The removal percentages shown are typical, but they can be influenced by pH and other conditions. The high TSS level is unusual for this technology and ultrafiltration is assumed to reduce the TSS level by one-thrid after mixed media filtration.

The permeate or effluent from the ultrafiltration unit is normally of a quality that can be reused in industrial applications or discharged directly. The concentrate from the ultrafiltration unit can be disposed of as any oily or solid waste.

Advantages and Limitations. Ultrafiltration is sometimes an attractive alternative to chemical treatment because of lower capital equipment, installation, and operating costs, very high oil and suspended solids removal, and little required pretreatment. It places a positive barrier between pollutants and effluent which reduces the possibility of extensive pollutant discharge due to operator error or upset in settling and skimming systems. Alkaline values in alkaline cleaning solutions can be recovered and reused in process.

A limitation of ultrafiltration for treatment of process effluents is its narrow temperature range (18° to 30°C) for satisfactory operation. Membrane life decreases with higher temperatures, but flux increases at elevated temperatures. Therefore, surface area requirements are a function of temperature and become a tradeoff between initial costs and replacement costs for the membrane. In addition, ultrafiltration cannot handle certain solutions. Strong oxidizing agents, solvents, and other organic compounds can dissolve the membrane. Fouling is sometimes a problem, although the high velocity of the wastewater normally creates enough turbulence to keep fouling at a minimum. Large solids particles can sometimes puncture the membrane and must be removed by gravity settling or filtration prior to the ultrafiltration unit.

Operational Factors. Reliability: The reliability of an ultrafiltration system is dependent on the proper filtration, settling or other treatment of incoming waste streams to prevent damage to the membrane. Careful pilot studies should be done in each instance to determine necessary pretreatment steps and the exact membrane type to be used.

Maintainability: A limited amount of regular maintenance is required for the pumping system. In addition, membranes must be periodically changed. Maintenance associated with membrane plugging can be reduced by selection of a membrane with optimum physical characteristics and sufficient velocity of the waste stream. It is often necessary to occasionally pass a detergent solution through the system to remove an oil and grease film which accumulates on the membrane. With proper maintenance membrane life can be greater than twelve months.

Solid Waste Aspects: Ultrafiltration is used primarily to recover solids and liquids. It therefore eliminates solid waste problems when the solids (e.g., paint solids) can be recycled to the process. Otherwise, the stream containing solids must be treated by end-of-pipe equipment. In the most probable applications within the coil coating category, the ultrafilter would remove hydroxides or sulfides of metals which have recovery value.

Demonstration Status. The ultrafiltration process is well developed and commercially available for treatment of wastewater or recovery of certain high molecular weight liquid and solid contaminants.

25. Vacuum Filtration

In wastewater treatment plants, sludge dewatering by vacuum filtration generally uses cylindrical drum filters. These drums have a filter medium which may be cloth made of natural or synthetic fibers or a wire-mesh fabric. The drum is suspended above and dips into a vat of sludge. As the drum rotates slowly, part of its circumference is subject to an internal vacuum that draws sludge to the filter medium. Water is drawn through the porous filter cake to a discharge port, and the dewatered sludge, loosened by compressed air, is scraped from the filter mesh. Because the dewatering of sludge on vacuum filters is relativley expensive per kilogram of water removed, the liquid sludge is frequently thickened prior to processing. A vacuum filter is shown in Figure VII-30 (page 305).

Application and Performance. Vacuum filters are frequently used both in municipal treatment plants and in a wide variety of industries. They are most commonly used in larger facilities, which may have a thickener to double the solids content of clarifier sludge before vacuum filtering.

The function of vacuum filtration is to reduce the water content of sludge, so that the solids content increases from about 5 percent to about 30 percent.

Advantages and Limitations. Although the initial cost and area requirement of the vacuum filtration system are higher than those of a centrifuge, the operating cost is lower, and no special provisions for sound and vibration protection need be made. The dewatered sludge from this process is in the form of a moist cake and can be conveniently handled.

Operational Factors. Reliability: Vacuum filter systems have proven reliable at many industrial and municipal treatment facilities. At present, the largest municipal installation is at the West Southwest waste water treatment plant of Chicago, Illinois, where 96 large filters were installed in 1925, functioned approximately 25 years, and then were replaced with larger units. Original vacuum filters at Minneapolis-St. Paul, Minnesota now have over 28 years of continuous service, and Chicago has some units with similar or greater service life.

Maintainability: Maintenance consists of the cleaning or replacement of the filter media, drainage grids, drainage piping, filter pans, and other parts of the equipment. Experience in a number of vacuum filter plants indicates that maintenance consumes approximately 5 to 15 percent of the total time. If carbonate buildup or other problems are unusually severe, maintenance time may be as high as 20 percent. For this reason, it is desirable to maintain one or more spare units.

If intermittent operation is used, the filter equipment should be drained and washed each time it is taken out of service. An allowance for this wash time must be made in filtering schedules.

Solid Waste Aspects: Vacuum filters generate a solid cake which is usually trucked directly to landfill. All of the metals extracted from the plant wastewater are concentrated in the filter cake as hydroxides, oxides, sulfides, or other salts.

Demonstration Status. Vacuum filtration has been widely used for many years. It is a fully proven, conventional technology for sludge dewatering.

IN-PLANT TECHNOLOGY

The intent of in-plant technology for the coil coating point source category is to reduce or eliminate the waste load requiring end-of-pipe treatment and thereby improve the efficiency of an existing wastewater treatment system or reduce the requirements of a new treatment system. In-plant technology involves improved rinsing, water conservation, process bath conservation, reduction of dragout, automatic controls, good housekeeping practices, recovery and reuse of process solutions, process modification and waste treatment. The in-plant technology has been divided into two areas:

In-process treatment and controls

Process substitutions

In-Process Treatment and Controls

In-process treatment and controls can apply to both existing and new installations and use technologies and methodologies that have already been developed. Coil coating operations consist of three main functional groups; cleaning, conversion coating and painting. Each of these operations is amenable to reduction of both chemical and water usage. These reductions in chemical and water usage are desirable because of the attendant reductions in pollutant discharge which results from treating smaller volumes of more concentrated waste streams.

A major portion of the oil, grease, dirt and oxide coating is removed from the coil by alkaline cleaning and rinsing. Cleaning of the coil is extremely important because incomplete cleaning adversely affects subsequent operations. The primary factors that adversely affect cleaning and rinsing efficiency are:

- Incorrect alkaline cleaning compound for basis material.
- Incorrect temperature of alkaline cleaning solution and rinse water.
- Insufficient number of spray nozzles or insufficient pressure for both alkaline cleaning and rinsing.
- Insufficient squeegee action to prevent excessive dragout of alkaline cleaning solution.
- Absence of bath equilibrium controls that automatically add make-up water and cleaning solution.
- Undefined soils
- Insufficient time

Alkaline cleaning solutions are formulated for specific basis materials. For example, the cleaning compound for steel is more alkaline than for galvanized or aluminum. The most advanced alkaline cleaning solutions contain phosphates that form soluble complexes with the dissolved basis materials rather than an insoluble sludge. The formation of an insoluble sludge may necessitate discarding the solution before exhausting all available alkalinity.

Operating temperature is as important as the proper alkaline cleaning solution and concentration. A solution that is too cold may not be able to dissolve either enough of the dry alkaline cleaning compound or the dirt, oil, grease and oxides from the coil. A solution that is too warm may set certain types of soil onto the coil itself, in the spray nozzles, or onto the tank. In addition, excessive temperature may cause excessive foaming.

Spray nozzles and pressures should be adequate to assure overlapping coverage of the work area. Experience will dictate how fast the coil can move and be effectively cleaned with a given set of spray nozzles and pressure.

Following the alkaline cleaning, squeegees are important to reduce dragout of the alkaline cleaning compounds. Excessive dragout reduces the rinsing rate and wastes cleaning materials. Of the thirteen visited plants, ten have dragout control in the form of squeegees or air knives somewhere in the line. Automatic alkalinity sensors can reduce the consumption of alkaline cleaning compounds; six of the visited plants used automatic controls to maintain bath equilibrium.

The use of alkaline cleaning rinse water as make-up to the alkaline cleaning tank can conserve water. Another applicable water conservation mechanism (particularly for new installations) is a countercurrent rinse. Multi-stage and countercurrent rinses are employed at many industrial plants. In many cases, however, these techniques are not combined with effective flow control, and the wastewater discharge volumes from the multi-stage or countercurrent rinses are as large as or larger than corresponding single stage rinse flows at other plants. Countercurrent rinsing is more efficient than multiple single stage rinses from the standpoint of water use. In countercurrent rinsing one fresh water feed is used for the last tank in the production sequence. The overfrom flow flow each tank in the production sequence becomes the feed for the tank preceeding it; the water flow from tank to tank cascades countercurrently to the products sequence.

Countercurrent Cascade Rinsing

Rinse water requirements and the benefits of countercurrent rinsing may be influenced by the volume of solution dragout carried into each rinse stage by the material being rinsed, by the number of rinse stages used, by the initial concentrations of impurities being removed, and by the final product cleanliness required. The influence of these factors is expressed in the rinsing equation which may be stated simply as:

$$V\underline{r} = \left(\frac{C\underline{o}}{C\underline{f}}\right)^{1}/n \ x \ VD$$

$V\underline{r}$ is the flow through each rinse stage.
$C\underline{o}$ is the concentration of the contaminant(s) in the initial process bath

$C\underline{f}$ is the concentration of the contaminant(s) in the final rinse to give acceptable product cleanliness.

n is the number of rinse stages employed

and

VD is the drag-out carried into each rinse stage, expressed as a flow

For a multi-stage rinse, the total volume of rinse wastewater is equal to n times V_r while for a countercurrent rinse the total volume of wastewater discharge equals V_r.

Drag-out is solution which remains on the surface of material being rinsed when it is removed from process baths or rinses.

Without specific plant data available to determine drag-out, we can make an estimate of rinse water reduction to be achieved with three-stage countercurrent rinsing by assuming a thickness of any process solution film as it is introduced into the rinse tank. If the film is 0.6 mil thick, (equivalent to the film on a well-drained vertical surface) then the volume of process solution, VD, carried into the rinse tank on one square meter of metal will be:

$$VD = 0.0006 \text{ in} \times \frac{2.54 \text{ cm}}{\text{in}} \times 144 \frac{\text{sq in}}{\text{sq ft}} \times (2.54)^2 \frac{\text{sq cm}}{\text{sq in}} \times$$

$$\frac{1 \text{ liter}}{1000 \text{ cu cm}} \times \frac{1 \text{ sq ft}}{0.0929 \text{ sq m}} = 0.015 \text{ l/m}^2 \text{ of metal}$$

To calculate the benefits of countercurrent rinsing for coil coating we assume a 3 stage countercurrent spray rinse is installed after alkaline cleaning and conversion coating operations. Using the mean subcategory cleaning rinse and conversion coating rinse water use from Table V-12 as V_r we have:

	Vr	
Subcategory	Cleaning	Conversion Coating
Steel	2.274	0.421
Galvanized	1.368	0.528
Aluminum	0.964	0.546

Let $r = \frac{C_o}{C_f}$ then $r^{1/n} = \frac{V_r}{VD}$

For single stage rinsing n = 1

therefore $r = \frac{V_r}{V_D}$

and:

	r	
Subcategory	Cleaning	Conversion Coating
Steel	151.6	28.1
Galvanized	91.2	35.2
Aluminum	64.3	36.4

And these are assumed to be the rinse ratios achieved for these operations at visited plants.

For a 3-stage countercurrent rinse to obtain the same r,

$\frac{V_r}{V_D} = r^{1/3}$ and:

	$\frac{V_R}{V_D}$	
Subcategory	Cleaning	Conversion Coating
Steel	5.33	3.04
Galvanized	4.50	3.28
Aluminum	4.01	3.31

But VD = 0.015
therefore for 3-stage countercurrent rinsing V_r is

	Vr /sq m	
Subcategory	Cleaning	Conversion Coating
Steel	0.080	0.046
Galvanized	0.068	0.049
Aluminum	0.060	0.050

Adding the water use for the cleaning rinse and conversion coating rinse gives the water use which can be achieved by substituting 3-stage countercurrent spray rinsing for each single stage spray rinse:

Subcategory	Combined Water Use 1/sq m
Steel	0.126
Galvanized	0.117
Aluminum	0.110

These numbers may vary depending on efficacy of squeegees or air knives, and the rinse ratio desired.

In Section XI of this document, water use allowances are based on practical considerations, assuming that 3-stage countercurrent spray rinsing is substituted for single stage spray rinsing. The overall water allowances are from 2.5 to 4.3 times the above water use which are derived from strictly theoretical considerations and limited to rinse water use, excluding batch dumps.

In-process Control

The conversion coating function is the heart of the coil coating operation. This is one of the steps in which material is added to the coil. The three types of conversion coating operations used are chromating, phosphating (either zinc or iron) and complex oxides.

A number of parameters require monitoring and control to maximize coating formation rate and minimize the amount of material discarded.

All types of conversion coating operations require careful monitoring and control of pH. If the pH is not kept at the optimum level, either the chemical reaction proceeds too slowly or the surface of the coil is excessively etched. The pH of the system can be sensed electronically and automatic make-up of specific chemicals performed in accordance with manufacturers' specifications. This control was used at six of the visited plants. Chemical suppliers provide a series of chemicals for each type of conversion coating. The series includes a bath make-up and one or two replenishment chemicals depending upon the constituent that has been depleted. This system maximizes use of all chemicals and provides for a continued high quality product.

Temperature must be constantly monitored and kept within an acceptable range. Low temperatures will slow film formation and high temperatures will degrade the freshly formed film. For a given coil speed, there should be adequate spray nozzle coverage and pressure. This assures that all areas of the coil have sufficient reaction time to allow buildup of a specified film thickness. After film formation, a set of squeegees is required to reduce dragout which wastes unreacted conversion coating chemicals and contaminates the subsequent sealing rinse.

The chromating conversion coating chemicals contain significant quantities of hexavalent and trivalent chromium. The hexavalent chromium eventually becomes reduced to trivalent chromium, precluding its use as part of the film. Certain chromating conversion coating systems are able to regenerate chromium. These systems pump chromating conversion coating solution out of the process tank to another tank where it is electrolytically regenerated. This application of electrical current to the solution increases the valance of the trivalent chromium to hexavalent chromium. The solution is then returned to the process tank. This chromium regeneration process was employed at two plants.

A sealing rinse is used for both phosphate and chromate conversion coatings. The sealing rinses are basically dilute solutions of chromic acid, phosphoric acid and sometimes certain metal ions such as zinc. Depending upon the type of conversion coating and basis material, various proportions of these constituents are used. This sealing rinse removes unreacted conversion coating chemicals from the film surface, thereby stopping the reactions and sealing the effective pore area of the film with a layer of chromium complexes. Similar to conversion coating operations, the solution must be maintained at proper temperatures and spray nozzle area and pressure must be adequate for the desired coil speed. The rinse can be recirculated and reused until dragged in conversion coating chemicals contaminate the bath, rinsing action is affected, or the chemicals themselves are depleted. Following the sealing rinse, good practice provides a squeegee roll and an air knife to prevent dragout and to prevent wet strip from entering the painting operation. The benefits of countercurrent rinsing for this step were discussed previously.

The subsequent painting and baking operations are followed by a water spray quench. This quench cools the basis material and films for either subsequent coats of paint or final rewinding. The freshly painted and cured surfaces are clean and stable and very little contamination of the quench water occurs. To conserve water and prevent dilution of other plant wastes discharging to treatment, quench water can either be recycled through a cooling tower, with make-up water added as needed, or reused as the cleaning or conversion coating rinse. Fifteen plants in the data base had the necessary equipment for partial or full quench water recycle. Five plants reused a portion of their quench water as the cleaning rinse.

In-Process Substitutions

The in-process substitutions for this industry involve only the conversion coating phases of the total operation. The alkaline cleaning, rinsing, painting, baking, and quenching operations remain virtually unchanged. These inprocess substitutions either eliminate the discharge of a significant pollutant or entirely eliminate discharge from the conversion coating operation.

Certain chromating solutions contain cyanide ions to promote faster reaction of the solution. Cyanide is a priority pollutant which requires separate treatment to remove it once in solution.

There are competing chemical systems that do not contain cyanide and efforts should be made to eliminate cyanide use where possible.

Certain sealing rinses contain zinc which, is also a priority pollutant and requires treatment before being discharged. Efforts should be made to incorporate and use sealing rinses that do not contain zinc. Several of the visited plants used non-zinc sealing rinses.

No-rinse conversion coating is a possible substitute for chromate conversion coating which can be applied to steel, galvanized and aluminum basis materials. The operation eliminates chromate conversion coating bath dumps and sealing rinse discharges by applying the coating with a roll coater. Existing lines require extensive modification to effectively use this technology. Three plants in the data base indicated that they currently use no-rinse conversion coating. The high line speeds and nature of no-rinse conversion coating require more precise control of cleaning, rinsing, and drying than a typical conversion coating line with rinsing. No-rinse conversion coating requires only liquid level monitoring as bath constituents are all depleted at the same rate. The benefits of countercurrent rinsing for this step were discussed previously.

TABLE VII-1
pH CONTROL EFFECT ON METALS REMOVAL

	Day 1		Day 2		Day 3	
	In	Out	In	Out	In	Out
pH Range	2.4-3.4	8.5-8.7	1.0-3.0	5.0-6.0	2.0-5.0	6.5-8.1
(mg/l)						
TSS	39	8	16	19	16	7
Copper	312	0.22	120	5.12	107	0.66
Zinc	250	0.31	32.5	25.0	43.8	0.66

TABLE VII-2

Effectiveness of Sodium Hydroxide for Metals Removal

	Day 1		Day 2		Day 3	
	In	Out	In	Out	In	Out
pH Range (mg/l)	2.1-2.9	9.0-9.3	2.0-2.4	8.7-9.1	2.0-2.4	8.6-9.1
Cr	0.097	0.0	0.057	0.005	0.068	0.005
Cu	0.063	0.018	0.078	0.014	0.053	0.019
Fe	9.24	0.76	15.5	0.92	9.41	0.95
Pb	1.0	0.11	1.36	0.13	1.45	0.11
Mn	0.11	0.06	0.12	0.044	0.11	0.044
Ni	0.077	0.011	0.036	0.009	0.069	0.011
Zn	.054	0.0	0.12	0.0	0.19	0.037
TSS		13		11		11

TABLE VII-3
Effectiveness of Lime and Sodium Hydroxide for Metals Removal

	Day 1		Day 2		Day 3	
	In	Out	In	Out	In	Out
pH Range (mg/l)	9.2-9.6	8.3-9.8	9.2	7.6-8.1	9.6	7.8-8.2
Al	37.3	0.35	38.1	0.35	29.9	0.35
Co	3.92	0.0	4.65	0.0	4.37	0.0
Cu	0.65	0.003	0.63	0.003	0.72	0.003
Fe	137	0.49	110	0.57	208	0.58
Mn	175	0.12	205	0.012	245	0.12
Ni	6.86	0.0	5.84	0.0	5.63	0.0
Se	28.6	0.0	30.2	0.0	27.4	0.0
Ti	143	0.0	125	0.0	115	0.0
Zn	18.5	0.027	16.2	0.044	17.0	0.01
TSS	4390	9	3595	13	2805	13

TABLE VII-4

THEORETICAL SOLUBILITIES OF HYDROXIDES AND SULFIDES OF SELECTED METALS IN PURE WATER

	Solubility of metal ion, mg/l		
Metal	As Hydroxide	As Carbonate	As Sulfide
Cadmium (Cd^{++})	2.3×10^{-5}	1.0×10^{-4}	6.7×10^{-1}
Chromium (Cr^{+++})	8.4×10^{-4}		No precipita
Cobalt (Co^{++})	2.2×10^{-1}		1.0×10^{-8}
Copper (Cu^{++})	2.2×10^{-2}		5.8×10^{-1}
Iron (Fe^{++})	8.9×10^{-1}		3.4×10^{-5}
Lead (Pb^{++})	2.1	7.0×10^{-3}	3.8×10^{-9}
Manganese (Mn^{++})	1.2		2.1×10^{-3}
Mercury (Hg^{++})	3.9×10^{-4}	3.9×10^{-2}	9.0×10^{-2}
Nickel (Ni^{++})	6.9×10^{-3}	1.9×10^{-1}	6.9×10^{-8}
Silver (Ag^{+})	13.3	2.1×10^{-1}	7.4×10^{-1}
Tin (Sn^{++})	1.1×10^{-4}		3.8×10^{-8}
Zinc (Zn^{++})	1.1	7.0×10^{-4}	2.3×10^{-7}

TABLE VII-5

SAMPLING DATA FROM SULFIDE PRECIPITATION-SEDIMENTATION SYSTEMS

Treatment	Lime, FeS, Poly-electrolyte, Settle, Filter		Lime, FeS, Poly-electrolyte, Settle, Filter		NaOH, Ferric Chloride, Na_2S Clarify (1 stage)	
	In	Out	In	Out	In	Out
pH	5.0-6.8	8-9	7.7	7.38		
(mg/l)						
Cr+6	25.6	<0.014	0.022	<0.020	11.45	<.005
Cr	32.3	<0.04	2.4	<0.1	18.35	<.005
Cu	-	-	-	-	0.029	0.003
Fe	0.52	0.10	108	0.6	-	-
Ni	-	-	0.68	<0.1	-	-
Zn	39.5	<0.07	33.9	<0.1	0.060	0.009

These data were obtained from three sources:

> Summary Report, Control and Treatment Technology for the Metal Finishing Industry: Sulfide Precipitation, USEPA, EPA No. 625/8/80-003, 1979.
>
> Industrial Finishing, Vol. 35, No. 11, November, 1979.
>
> Electroplating sampling data from plant 27045.

TABLE VII-6

SULFIDE PRECIPITATION-SEDIMENTATION PERFORMANCE

Parameter	Treated Effluent (mg/l)
Cd	0.01
CrT	0.05
Cu	0.05
Pb	0.01
Hg	0.03
Ni	0.05
Ag	0.05
Zn	0.01

Table VII-6 is based on two reports:

> Summary Report, Control and Treatment Technology for the Metal Finishing Industry: Sulfide Precipitation, USEPA, EPA No. 625/8/80-003, 1979.
>
> Addendum to Development Document for Effluent Limitations Guidelines and New Source Performance Standards, Major Inorganic products Segment of Inorganics Point Source Category, USEPA., EPA Contract No. EPA=68-01-3281 (Task 7), June, 1978.

Table VII-7

FERRITE CO-PRECIPITATION PERFORMANCE

Metal	Influent(mg/l)	Effluent(mg/l)
Mercury	7.4	0.001
Cadmium	240	0.008
Copper	10	0.010
Zinc	18	0.016
Chromium	10	<0.010
Manganese	12	0.007
Nickel	1,000	0.200
Iron	600	0.06
Bismuth	240	0.100
Lead	475	0.010

NOTE: These data are from:
Sources and Treatment of Wastewater in the Nonferrous Metals Industry, USEPA, EPA No. 600/2-80-074, 1980.

TABLE VII-8

CONCENTRATION OF TOTAL CYANIDE
(mg/l)

Plant	Method	In	Out
1057	$FeSO_4$	2.57	0.024
		2.42	0.015
		3.28	0.032
33056	$FeSO_4$	0.14	0.09
		0.16	0.09
12052	$ZnSO_4$	0.46	0.14
		0.12	0.06
Mean			0.07

Table VII-9

Multimedia Filter Performance

Plant ID #	TSS Effluent Concentration, mg/l
06097	0.0, 0.0, 0.5
13924	1.8, 2.2, 5.6, 4.0, 4.0, 3.0, 2.2, 2.8 3.0, 2.0, 5.6, 3.6, 2.4, 3.4
18538	1.0
30172	1.4, 7.0, 1.0
36048	2.1, 2.6, 1.5
mean	2.61

TABLE VII-10
PERFORMANCE OF SELECTED SETTLING SYSTEMS

PLANT ID	SETTLING DEVICE	SUSPENDED SOLIDS CONCENTRATION (mg/l)					
		Day 1		Day 2		Day 3	
		In	Out	In	Out	In	Out
01057	Lagoon	54	6	56	6	50	5
09025	Clarifier Settling Ponds	1100	9	1900	12	1620	5
11058	Clarifier	451	17	-	-	-	-
12075	Settling Pond	284	6	242	10	502	14
19019	Settling Tank	170	1	50	1	-	-
33617	Clarifier & Lagoon	-	-	1662	16	1298	4
40063	Clarifier	4390	9	3595	12	2805	13
44062	Clarifier	182	13	118	14	174	23
46050	Settling Tank	295	10	42	10	153	8

Table VII-11

SKIMMING PERFORMANCE

Plant	Skimmer Type	Oil & Grease mg/l In	Oil & Grease mg/l Out
06058	API	224,669	17.9
06058	Belt	19.4	8.3

TABLE VII-12

SELECTED PARITION COEFFICIENTS

PAH Priority Pollutant		Log Octanol/Water Partition Coefficient
1	Acenaphthene	4.33
39	Fluoranthene	5.33
72	Benzo(a)anthracene	5.61
73	Benzo(a)pyrene	6.04
74	3,4-benzofluoranthene	6.57
75	Benzo(k)fluoranthene	6.84
76	Chrysene	5.61
77	Acenaphthylene	4.07
78	Anthracene	4.45
79	Benzo(ghi)perylene	7.23
80	Fluorene	4.18
81	Phenanthrene	4.46
82	Dibenzo(a,h)anthracene	5.97
83	Indeno(1,2,3,cd)pyrene	7.66
84	Pyrene	5.32

TABLE VII-13

TRACE ORGANIC REMOVAL BY SKIMMING
API PLUS BELT SKIMMERS
(From Plant 06058)

	Inf.	Eff.
Oil & Grease	225,000	14.6
Chloroform	0.023	0.007
Methylene Chloride	0.013	0.012
Naphthalene	2.31	0.004
N-nitrosodiphenylamine	59.0	0.182
Bis-2-ethylhexylphthalate	11.0	0.027
Diethyl phthalate	-	-
Butylbenzylphthalate	0.005	0.002
Di-n-octyl phthalate	0.019	0.002
Anthracene - phenanthrene	16.4	0.014
Toluene	0.02	0.012

Table VII-14

COMBINED METALS DATA EFFLUENT VALUES (mg/l)

	Mean	One Day Max.	10 Day Avg. Max.	30 Day Avg. Max.
Cd	0.079	0.32	0.15	0.13
Cr	0.08	0.42	0.17	0.12
Cu	0.58	1.90	1.00	0.73
Pb	0.12	0.15	0.13	0.12
Ni	0.57	1.41	1.00	0.75
Zn	0.30	1.33	0.56	0.41
Fe	0.41	1.23	0.63	0.51
Mn	0.21	0.43	0.34	0.27
TSS	12.0	41.0	20.0	15.5

TABLE VII-15
L&S PERFORMANCE
ADDITIONAL POLLUTANTS

Pollutant	Average Performance (mg/l)
Sb	0.7
As	0.51
Be	0.30
Hg	0.06
Se	0.30
Ag	0.10
Th	0.50
Al	1.11
Co	0.05
F	14.5

TABLE VII-16

COMBINED METALS DATA SET - UNTREATED WASTEWATER

Pollutant	Min. Conc (mg/l)	Max. Conc. (mg/l)
Cd	<0.1	3.83
Cr	<0.1	116
Cu	<0.1	108
Pb	<0.1	29.2
Ni	<0.1	27.5
Zn	<0.1	337.
Fe	<0.1	263
Mn	<0.1	5.98
TSS	4.6	4390

TABLE VII-17
MAXIMUM POLLUTANT LEVEL IN UNTREATED WASTEWATER

ADDITIONAL POLLUTANTS
(mg/l)

Pollutant	As & Se	Be	Ag	F
As	4.2	-	-	-
Be	-	10.24	-	-
Cd	<0.1	-	<0.1	<0.1
Cr	0.18	8.60	0.23	22.8
Cu	33.2	1.24	110.5	2.2
Pb	6.5	0.35	11.4	5.35
Ni	-	-	100	0.69
Ag	-	-	4.7	-
Zn	3.62	0.12	1512	<0.1
F	-	-	-	760
Fe	-	646	-	-
O&G	16.9	-	16	2.8
TSS	352	796	587.8	5.6

TABLE VII-18

PRECIPITATION-SETTLING-FILTRATION (LS&F) PERFORMANCE
Plant A

Parameters	No Pts.	Range mg/l	Mean ± std. dev.	Mean + 2 std. dev.
For 1979-Treated Wastewater				
Cr	47	0.015 - 0.13	0.045 ±0.029	0.10
Cu	12	0.01 - 0.03	0.019 ±0.006	0.03
Ni	47	0.08 - 0.64	0.22 ±0.13	0.48
Zn	47	0.08 - 0.53	0.17 ±0.09	0.35
Fe				
For 1978-Treated Wastewater				
Cr	47	0.01 - 0.07	0.06 ±0.10	0.26
Cu	28	0.005 - 0.055	0.016 ±0.010	0.04
Ni	47	0.10 - 0.92	0.20 ±0.14	0.48
Zn	47	0.08 - 2.35	0.23 ±0.34	0.91
Fe	21	0.26 - 1.1	0.49 ±0.18	0.85
Raw Waste				
Cr	5	32.0 - 72.0		
Cu	5	0.08 - 0.45		
Ni	5	1.65 - 20.0		
Zn	5	33.2 - 32.0		
Fe	5	10.0 - 95.0		

TABLE VII-19

PRECIPITATION-SETTLING-FILTRATION (LS&F) PERFORMANCE
Plant B

Parameters	No Pts.	Range mg/l	Mean ± std. dev.	Mean + 2 std. dev.
For 1979-Treated Wastewater				
Cr	175	0.0 - 0.40	0.068 ±0.075	0.22
Cu	176	0.0 - 0.22	0.024 ±0.021	0.07
Ni	175	0.01 - 1.49	0.219 ±0.234	0.69
Zn	175	0.01 - 0.66	0.054 ±0.064	0.18
Fe	174	0.01 - 2.40	0.303 ±0.398	1.10
TSS	2	1.00 - 1.00		
For 1978-Treated Wastewater				
Cr	144	0.0 - 0.70	0.059 ±0.088	0.24
Cu	143	0.0 - 0.23	0.017 ±0.020	0.06
Ni	143	0.0 - 1.03	0.147 ±0.142	0.43
Zn	131	0.0 - 0.24	0.037 ±0.034	0.11
Fe	144	0.0 - 1.76	0.200 ±0.223	0.47
Total 1974-1979-Treated Wastewater				
Cr	1288	0.0 - 0.56	0.038 ±0.055	0.15
Cu	1290	0.0 - 0.23	0.011 ±0.016	0.04
Ni	1287	0.0 - 1.88	0.184 ±0.211	0.60
Zn	1273	0.0 - 0.66	0.035 ±0.045	0.13
Fe	1287	0.0 - 3.15	0.402 ±0.509	1.42
Raw Waste				
Cr	3	2.80 - 9.15	5.90	
Cu	3	0.09 - 0.27	0.17	
Ni	3	1.61 - 4.89	3.33	
Zn	2	2.35 - 3.39		
Fe	3	3.13 -35.9	22.4	
TSS	2	177 -466.		

TABLE VII-20

PRECIPITATION-SETTLING-FILTRATION (LS&F) PERFORMANCE
Plant C

For Treated Wastewater

Parameters	No Pts.	Range mg/l	Mean ± std. dev.	Mean + 2 std. dev.
For Treated Wastewater				
Cd	103	0.010 - 0.500	0.049 ±0.049	0.147
Zn	103	0.039 - 0.899	0.290 ±0.131	0.552
TSS	103	0.100 - 5.00	1.244 ±1.043	3.33
pH	103	7.1 - 7.9	9.2*	
For Untreated Wastewater				
Cd	103	0.039 - 2.319	0.542 ±0.381	1.304
Zn	103	0.949 -29.8	11.009 ±6.933	24.956
Fe	3	0.107 - 0.46	0.255	
TSS	103	0.80 -19.6	5.616 ±2.896	11.408
pH	103	6.8 - 8.2	7.6*	

* pH value is median of 103 values.

TABLE VII-21

Summary of Treatment Effectiveness
(mg/l)

Pollutant Parameter	L&S Technology System				LS&F Technology System			
	Mean	One Day Max.	Ten Day Avg.	Thirty Day Avg.	Mean	One Day Max.	Ten Day Avg.	Thirty Day Avg.
114 Sb	0.70	2.87	1.28	1.14	0.47	1.93	0.86	0.76
115 As	0.51	2.09	0.86	0.83	0.34	1.39	0.57	0.55
117 Be	0.30	1.23	0.51	0.49	0.20	0.82	0.34	0.32
118 Cd	0.079	0.32	0.15	0.13	0.049	0.20	0.08	0.08
119 Cr	0.080	0.42	0.17	0.12	0.07	0.37	0.15	0.10
120 Cu	0.58	1.90	1.00	0.73	0.39	1.28	0.61	0.49
121 CN	0.07	0.29	0.12	0.11	0.047	0.20	0.08	0.08
122 Pb	0.12	0.15	0.13	0.12	0.08	0.10	0.09	0.08
123 Hg	0.06	0.25	0.10	0.10	0.036	0.15	0.06	0.06
124 Ni	0.57	1.41	1.00	0.75	0.22	0.55	0.37	0.29
125 Se	0.30	1.23	0.55	0.49	0.20	0.82	0.37	0.33
126 Ag	0.10	0.41	0.17	0.16	0.07	0.29	0.12	0.10
127 Tl	0.50	2.05	0.84	0.81	0.34	1.40	0.57	0.55
128 Zn	0.30	1.33	0.56	0.41	0.23	1.02	0.42	0.31
Al	1.11	4.55	1.86	1.80	0.74	3.03	1.24	1.20
Co	0.05	0.21	0.09	0.08	0.034	0.14	0.07	0.06
F	14.5	59.5	26.4	23.5	9.67	39.7	17.6	15.7
Fe	0.41	1.23	0.63	0.51	0.28	1.23	0.63	0.51
Mn	0.21	0.43	0.34	0.27	0.14	0.30	0.23	0.19
P	4.08	16.7	6.83	6.60	2.72	11.2	4.6	4.4
O&G		20.0	12.0	10.0		10.0	10.0	10.0
TSS	12.0	41.0	20.0	15.5	2.6	15.0	12.0	10.0

TABLE VII-22
TREATABILITY RATING OF PRIORITY POLLUTANTS UTILIZING CARBON ADSORPTION

Priority Pollutant	*Removal Rating
1. acenaphthene	H
2. acrolein	L
3. acrylonitrile	L
4. benzene	M
5. benzidine	H
6. carbon tetrachloride (tetrachloromethane)	M
7. chlorobenzene	H
8. 1,2,3-trichlorobenzene	H
9. hexachlorobenzene	H
10. 1,2-dichloroethane	M
11. 1,1,1-trichloroethane	M
12. hexachloroethane	H
13. 1,1-dichloroethane	M
14. 1,1,2-trichloroethane	M
15. 1,1,2,2-tetrachlorethane	H
16. chloroethane	L
17. bis(chloromethyl) ether	-
18. bis(2-chloroethyl) ether	M
19. 2-chloroethylvinyl ether (mixed)	L
20. 2-chloronaphthalene	H
21. 2,4,6-trichlorophenol	H
22. parachlorometa cresol	H
23. chloroform (trichloromethane)	L
24. 2-chlorophenol	H
25. 1,2-dichlorobenzene	H
26. 1,3-dichlorobenzene	H
27. 1,4-dichlorobenzene	H
28. 3,3'-dichlorobenzidine	H
29. 1,1-dichloroethylene	L
30. 1,2-trans-dichloroethylene	L
31. 2,4-dichlorophenol	H
32. 1,2-dichloropropane	M
33. 1,2-dichloropropylene (1,3-dichloropropene)	M
34. 2,4-dimethylphenol	H
35. 2,4-dinitrotoluene	H
36. 2,6-dinitrotoluene	H
37. 1,2-diphenylhydrazine	H
38. ethylbenzene	M
39. fluoranthene	H
40. 4-chlorophenyl phenyl ether	H
41. 4-bromophenyl phenyl ether	H
42. bis(2-chloroisopropyl)ether	M
43. bis(2-chloroethoxy)methane	M
44. methylene chloride (dichloromethane)	L
45. methyl chloride (chloromethane)	L
46. methyl bromide (bromomethane)	L
47. bromoform (tribromomethane)	H
48. dichlorobromomethane	M
49. trichlorofluoromethane	M
50. dichlorodifluoromethane	L
51. chlorodibromomethane	M
52. hexachlorobutadiene	H
53. hexachlorocyclopentadiene	H
54. isophorone	H
55. naphthalene	H
56. nitrobenzene	H
57. 2-nitrophenol	H
58. 4-nitrophenol	H
59. 2,4-dinitrophenol	H
60. 4,6-dinitro-o-cresol	H
61. N-nitrosodimethylamine	M
62. N-nitrosodiphenylamine	H
63. N-nitrosodi-n-propylamine	M
64. pentachlorophenol	H
65. phenol	M
66. bis(2-ethylhexyl)phthalate	H
67. butyl benzyl phthalate	H
68. di-n-butyl phthalate	H
69. di-n-octyl phthalate	H
70. diethyl phthalate	H
71. dimethyl phthalate	H
72. 1,2-benzanthracene (benzo(a)anthracene)	H
73. benzo(a)pyrene (3,4-benzopyrene)	H
74. 3,4-benzofluoranthene (benzo(b)fluoranthene)	H
75. 11,12-benzofluoranthene (benzo(k)fluoranthene)	H
76. chrysene	H
77. acenaphthylene	H
78. anthracene	H
79. 1,12-benzoperylene (benzo (ghi)-perylene)	H
80. fluorene	H
81. phenanthrene	H
82. 1,2,3,6-dibenzanthracene (dibenzo(a,h) anthracene)	H
83. indeno (1,2,3-cd) pyrene (2,3-o-phenylene pyrene)	H
84. pyrene	-
85. tetrachloroethylene	M
86. toluene	M
87. trichloroethylene	L
88. vinyl chloride (chloroethylene)	L
106. PCB-1242 (Aroclor 1242)	H
107. PCB-1254 (Aroclor 1254)	H
108. PCB-1221 (Aroclor 1221)	H
109. PCB-1332 (Aroclor 1232)	H
110. PCB-1248 (Aroclor 1248)	H
111. PCB-1260 (Aroclor 1260)	H
112. PCB-1016 (Aroclor '016)	H

*Note Explanation of Removal Ratings

Category H (high removal)

adsorbs at levels ≥ 100 mg/g carbon at C_f = 10 mg/l

adsorbs at levels ≥ 100 mg/g carbon at C_f < 1.0 mg/l

Category M (moderate removal)

adsorbs at levels ≥ 100 mg/g carbon at C_f = 10 mg/l

adsorbs at levels ≤ 100 mg/g carbon at C_f < 1.0 mg/l

Category L (low removal)

adsorbs at levels < 100 mg/g carbon at C_f = 10 mg/l

adsorbs at levels < 10 mg/g carbon at C_f < 1.0 mg/l

C_f = final concentrations of priority pollutant at equilibrium

TABLE VII - 23

CLASSES OF ORGANIC COMPOUNDS ADSORBED ON CARBON

Organic Chemical Class	Examples of Chemical Class
Aromatic Hydrocarbons	benzene, toluene, xylene
Polynuclear Aromatics	naphthalene, anthracene biphenyls
Chlorinated Aromatics	chlorobenzene, polychlorinated biphenyls, aldrin, endrin, toxaphene, DDT
Phenolics	phenol, cresol, resorcenol and polyphenyls
Chorinated Phenolics	trichlorophenol, pentachlorophenol
*High Molecular Weight Aliphatic and Branch Chain hydrocarbons	gasoline, kerosine
Chlorinated Aliphatic hydrocarbons	carbon tetrachloride, perchloroethylene
*High Molecular Weight Aliphatic Acids and Aromatic Acids	tar acids, benzoic acid
*High Molecular Weight Aliphatic Amines and Aromatic Amines	aniline, toluene diamine
*High Molecular Weight Ketones, Esters, Ethers and Alcohols	hydroquinone, polyethylene glycol
Surfactants	alkyl benzene sulfonates
Soluble Organic Dyes	methylene blue, indigo carmine

---

* High Molecular Weight includes compounds in the broad range of from 4 to 20 carbon atoms

Table VII-24

ACTIVATED CARBON PERFORMANCE (MERCURY)

Plant	Mercury levels - mg/l	
	In	Out
A	28.0	0.9
B	0.36	0.015
C	0.008	0.0005

Table VII-25

Ion Exchange Performance

Parameter	Plant A		Plant B	
All Values mg/l	Prior To Purification	After Purification	Prior To Purification	After Purification
Al	5.6	0.20	-	-
Cd	5.7	0.00	-	-
Cr+3	3.1	0.01	-	-
Cr+6	7.1	0.01	-	-
Cu	4.5	0.09	43.0	0.10
CN	9.8	0.04	3.40	0.09
Au	-	-	2.30	0.10
Fe	7.4	0.01	-	-
Pb	-	-	1.70	0.01
Mn	4.4	0.00	-	-
Ni	6.2	0.00	1.60	0.01
Ag	1.5	0.00	9.10	0.01
SO4	-	-	210.00	2.00
Sn	1.7	0.00	1.10	0.10
Zn	14.8	0.40	-	-

Table VII-26

MEMBRANE FILTRATION SYSTEM EFFLUENT

Specific Metal	Manufacturers Guarantee	Plant 19066		Plant 31022		Predicted Performance
		In	Out	In	Out	
Al	0.5	---	---	---	---	
Cr, (+6)	0.02	0.46	0.01	5.25	<0.005	
Cr (T)	0.03	4.13	0.018	98.4	0.057	0.05
Cu	0.1	18.8	0.043	8.00	0.222	0.20
Fe	0.1	288	0.3	21.1	0.263	0.30
Pb	0.05	0.652	0.01	0.288	0.01	0.05
CN	0.02	<0.005	<0.005	<0.005	<0.005	0.02
Ni	0.1	9.56	0.017	194	0.352	0.40
Zn	0.1	2.09	0.046	5.00	0.051	0.10
TSS	---	632	0.1	13.0	8.0	1.0

Advantages and Limitations.

Table VII-27

PEAT ADSORPTION PERFORMANCE

Pollutant (mg/l)	In	Out
Cr+6	35,000	0.04
Cu	250	0.24
CN	36.0	0.7
Pb	20.0	0.025
Hg	1.0	0.02
Ni	2.5	0.07
Ag	1.0	0.05
Sb	2.5	0.9
Zn	1.5	0.25

Table VII-28

ULTRAFILTRATION PERFORMANCE

Parameter	Feed (mg/l)	Permeate (mg/l)
Oil (freon extractable)	1230	4
COD	8920	148
TSS	1380	13
Total Solids	2900	296

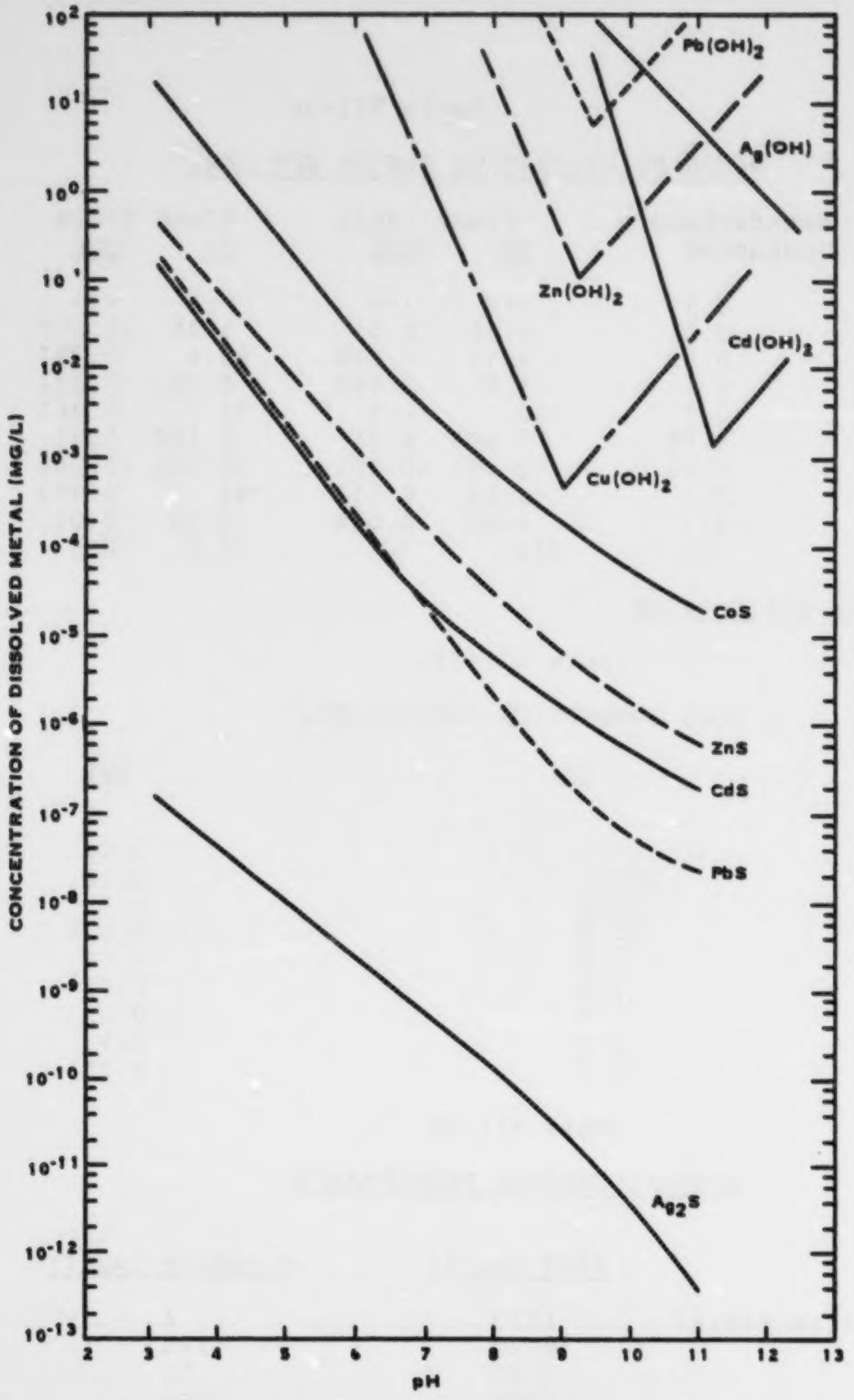


FIGURE VII-1. COMPARATIVE SOLUBILITIES OF METAL HYDROXIDES AND SULFIDE AS A FUNCTION OF pH

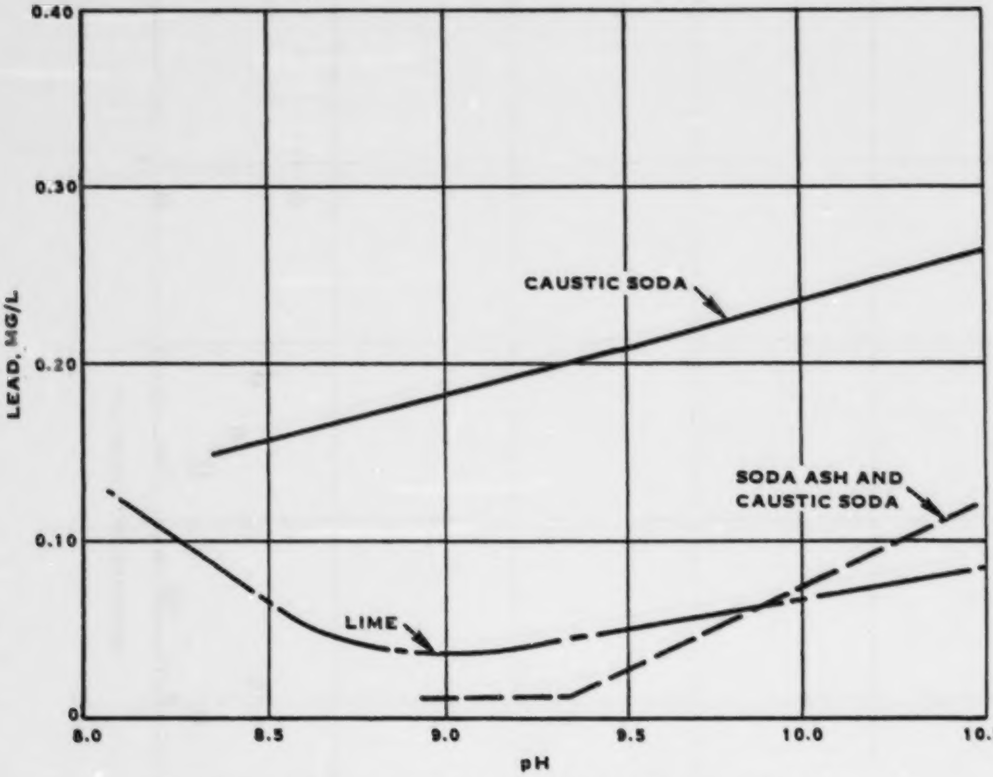


FIGURE VII-2. LEAD SOLUBILITY IN THREE ALKALIES

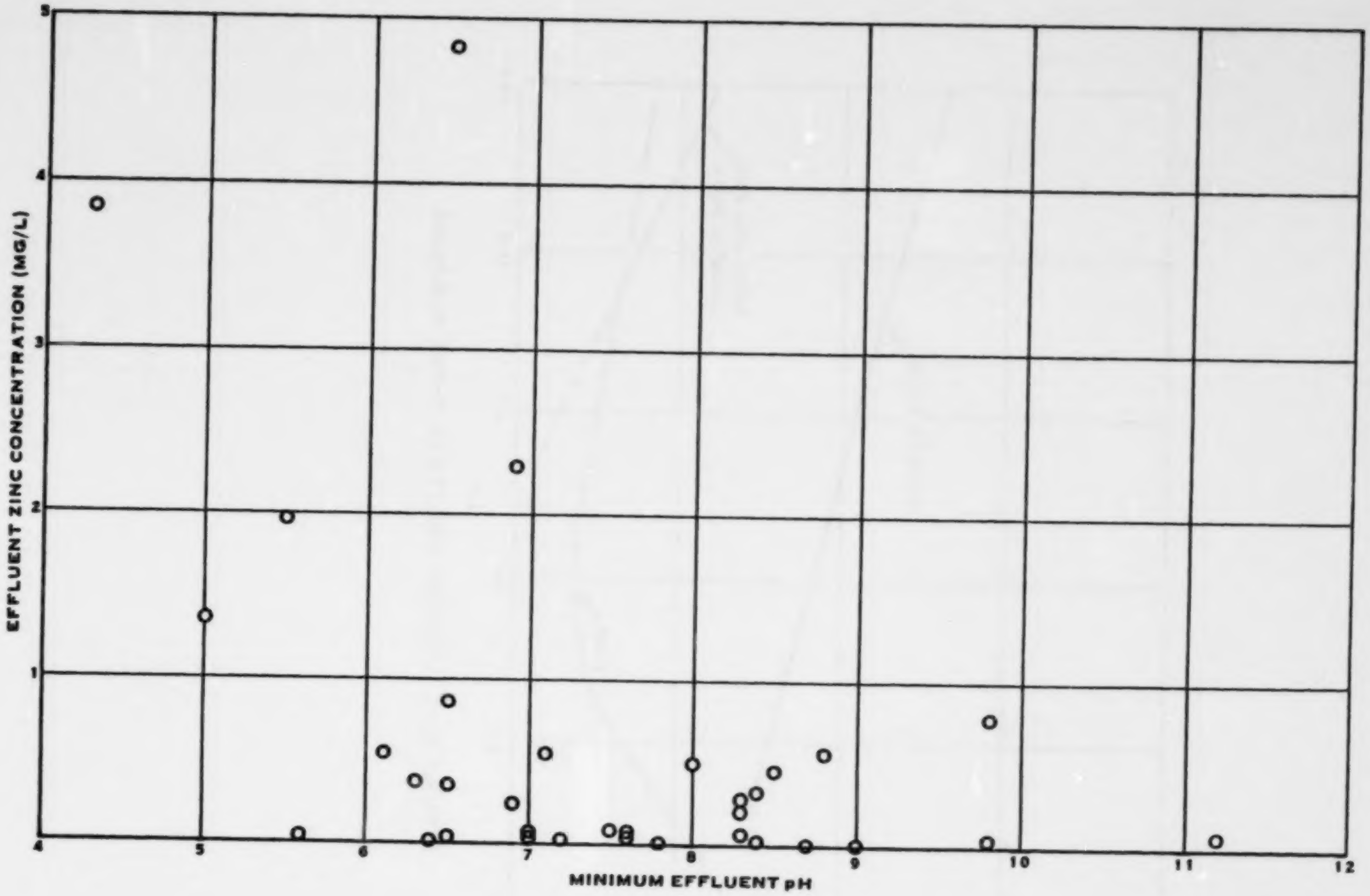
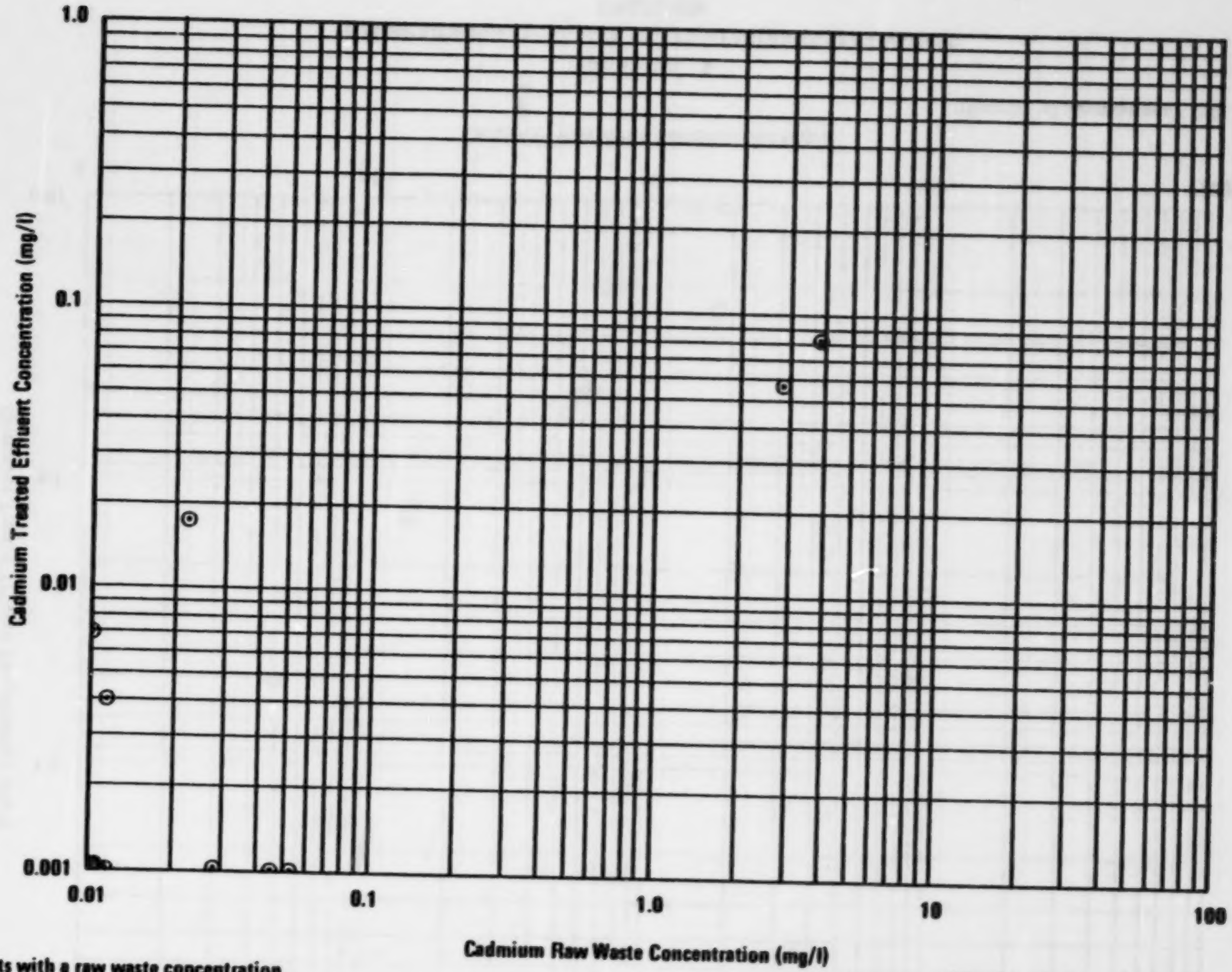


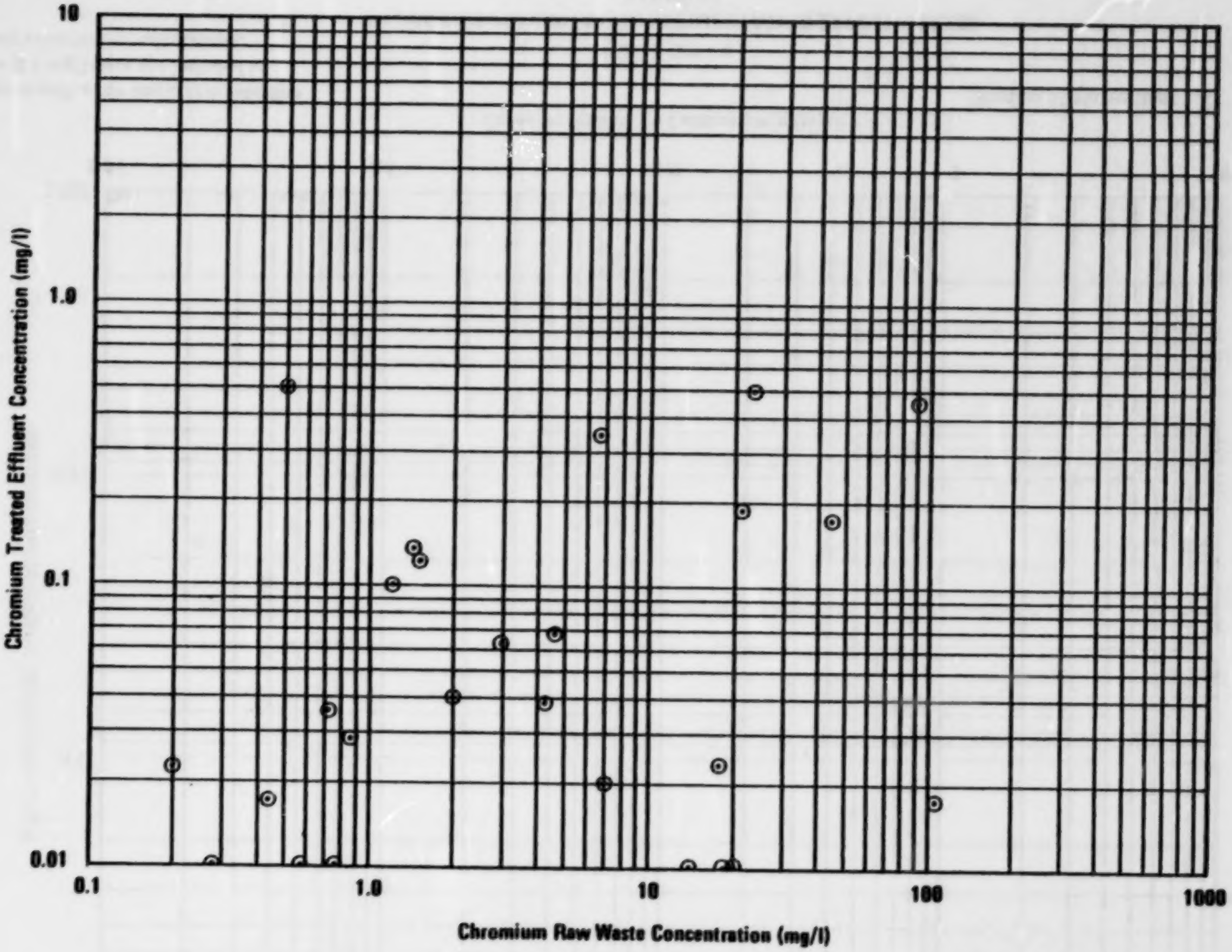
FIGURE VII-3. EFFLUENT ZINC CONCENTRATION VS. MINIMUM EFFLUENT pH



Data points with a raw waste concentration less than 0.1 mg/l were not included in treatment effectiveness calculations.

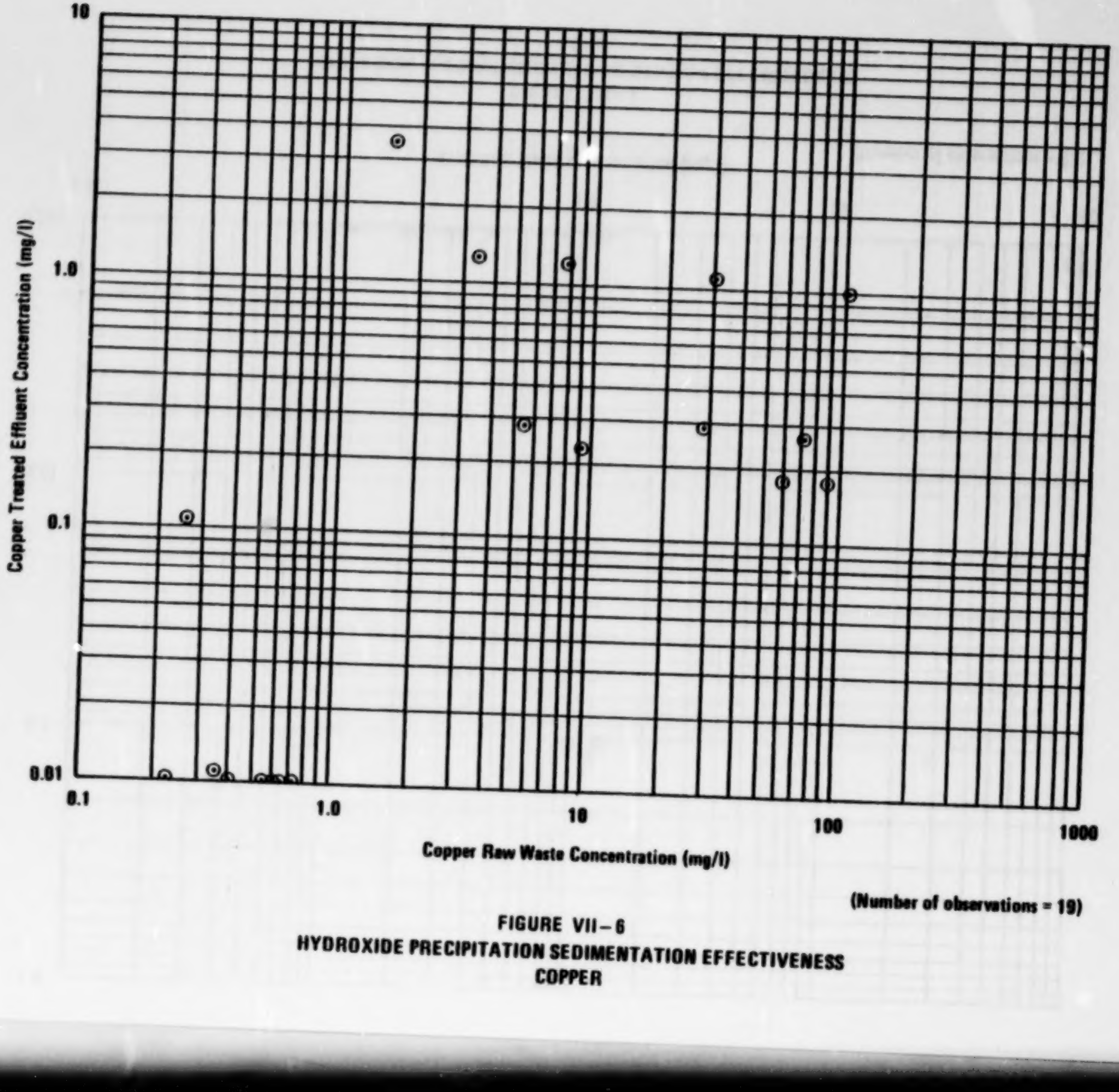
(Number of observations = 2)

FIGURE VII – 4
HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
CADMIUM



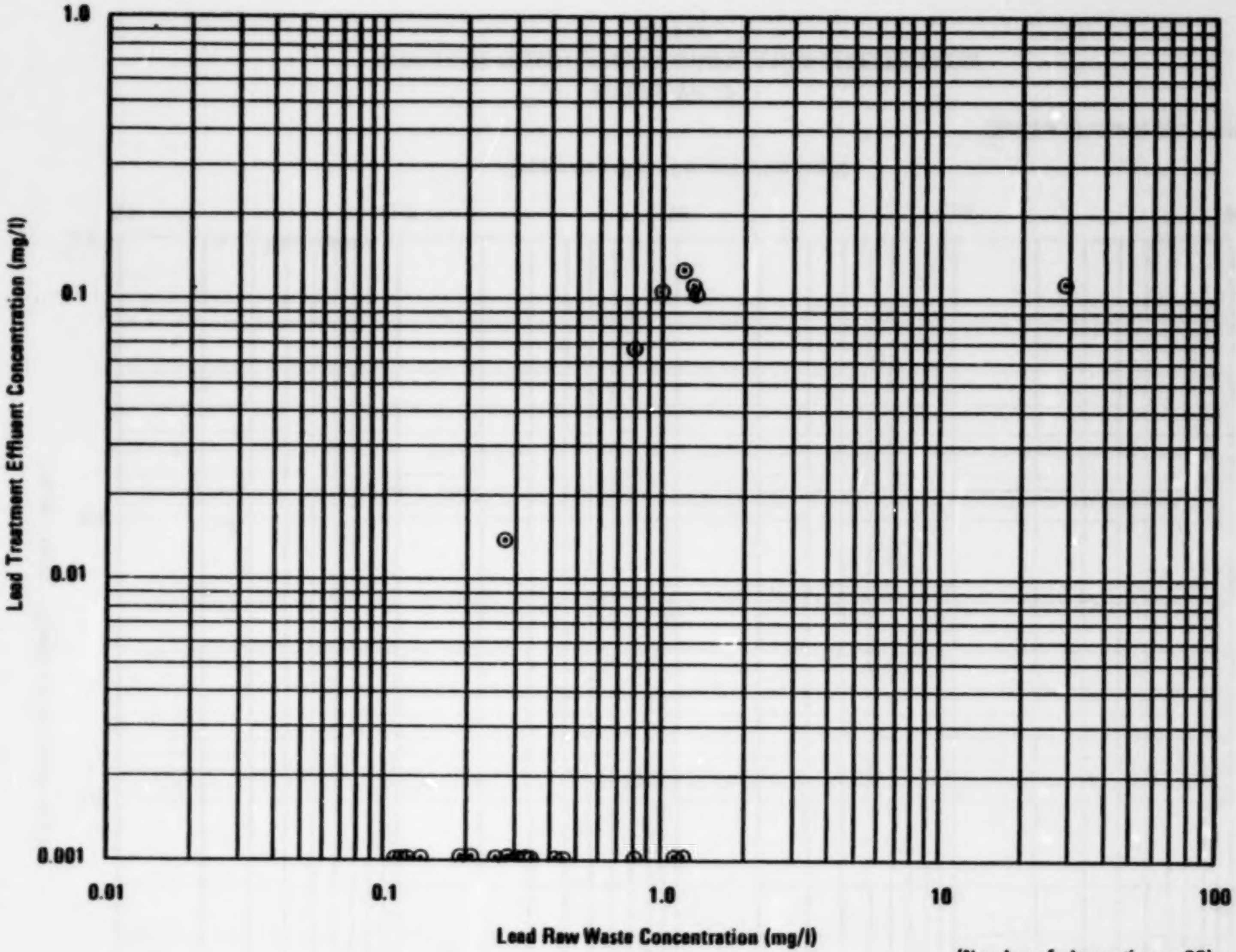
(Number of observations = 26)

FIGURE VII-5
HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
CHROMIUM



(Number of observations = 19)

FIGURE VII-6
HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
COPPER



(Number of observations = 23)

FIGURE VII-7
HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
LEAD

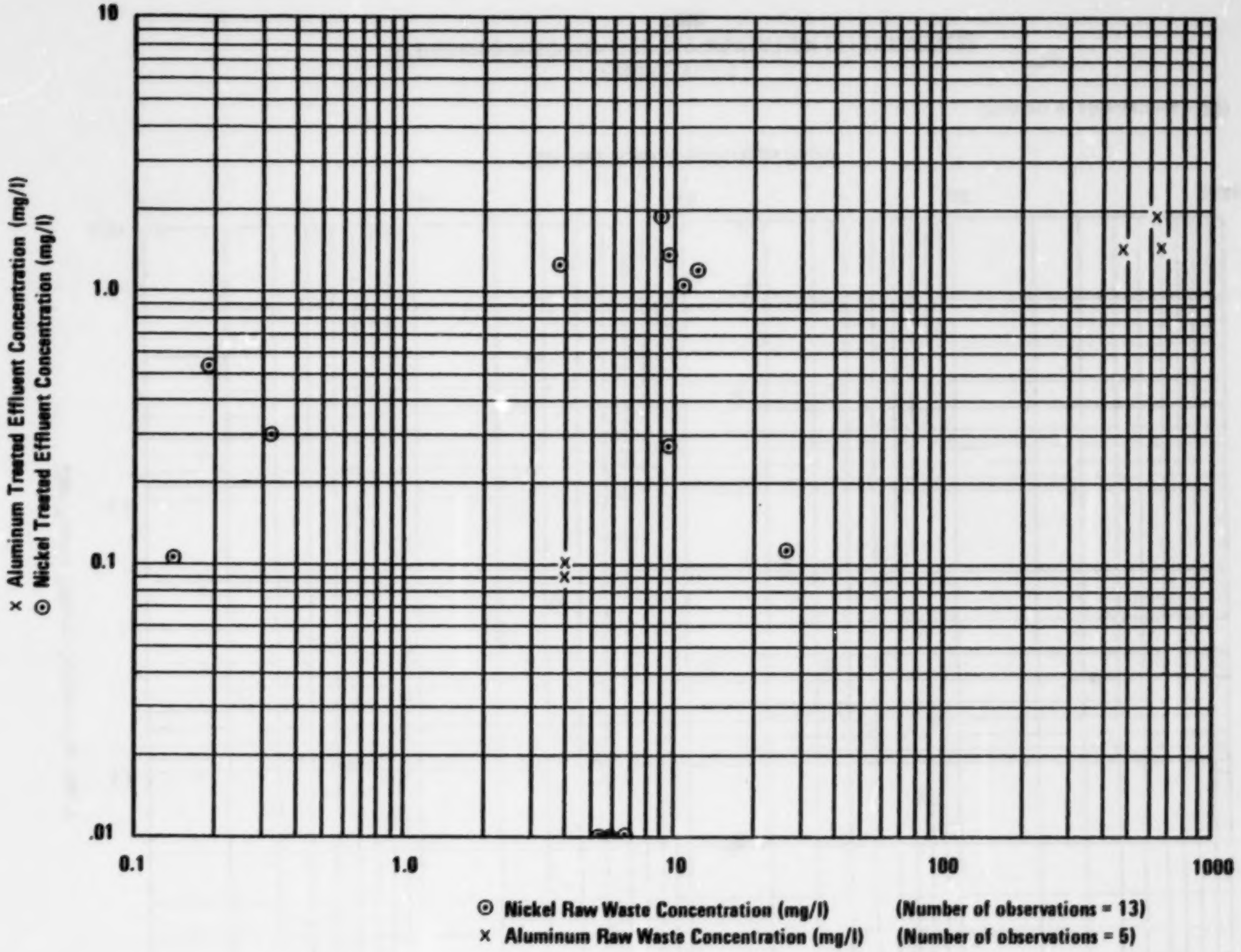
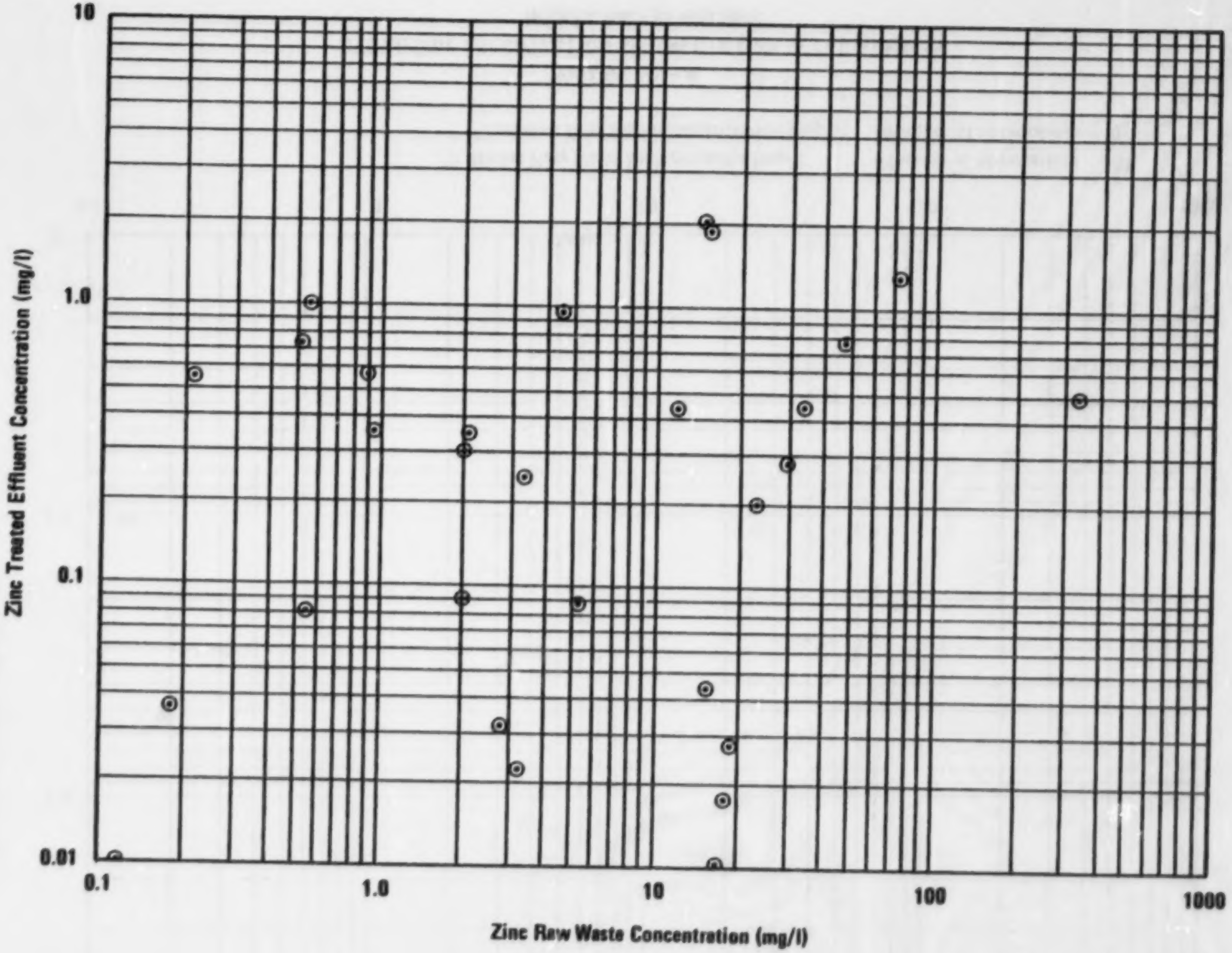
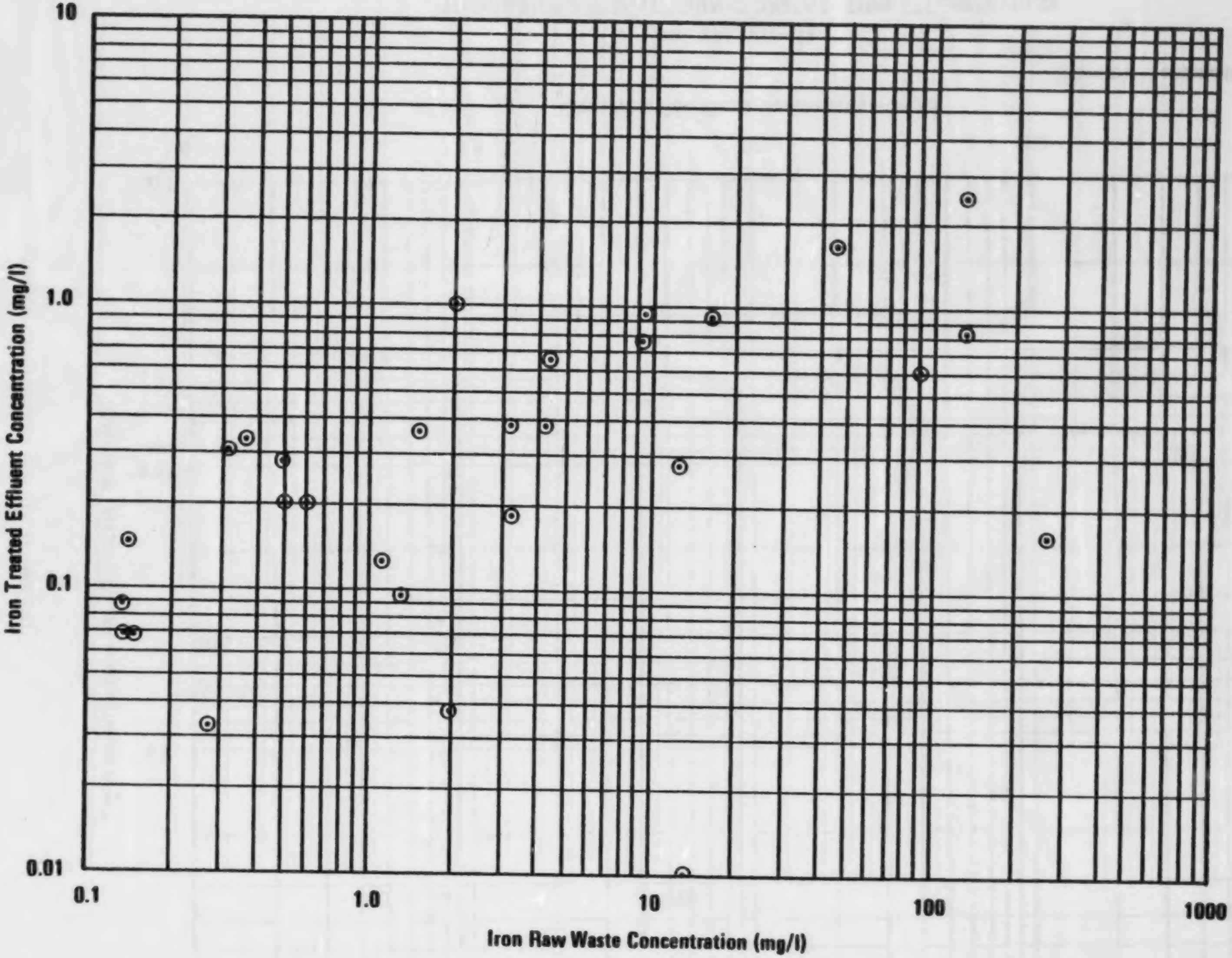


FIGURE VII-8
HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
NICKEL AND ALUMINUM



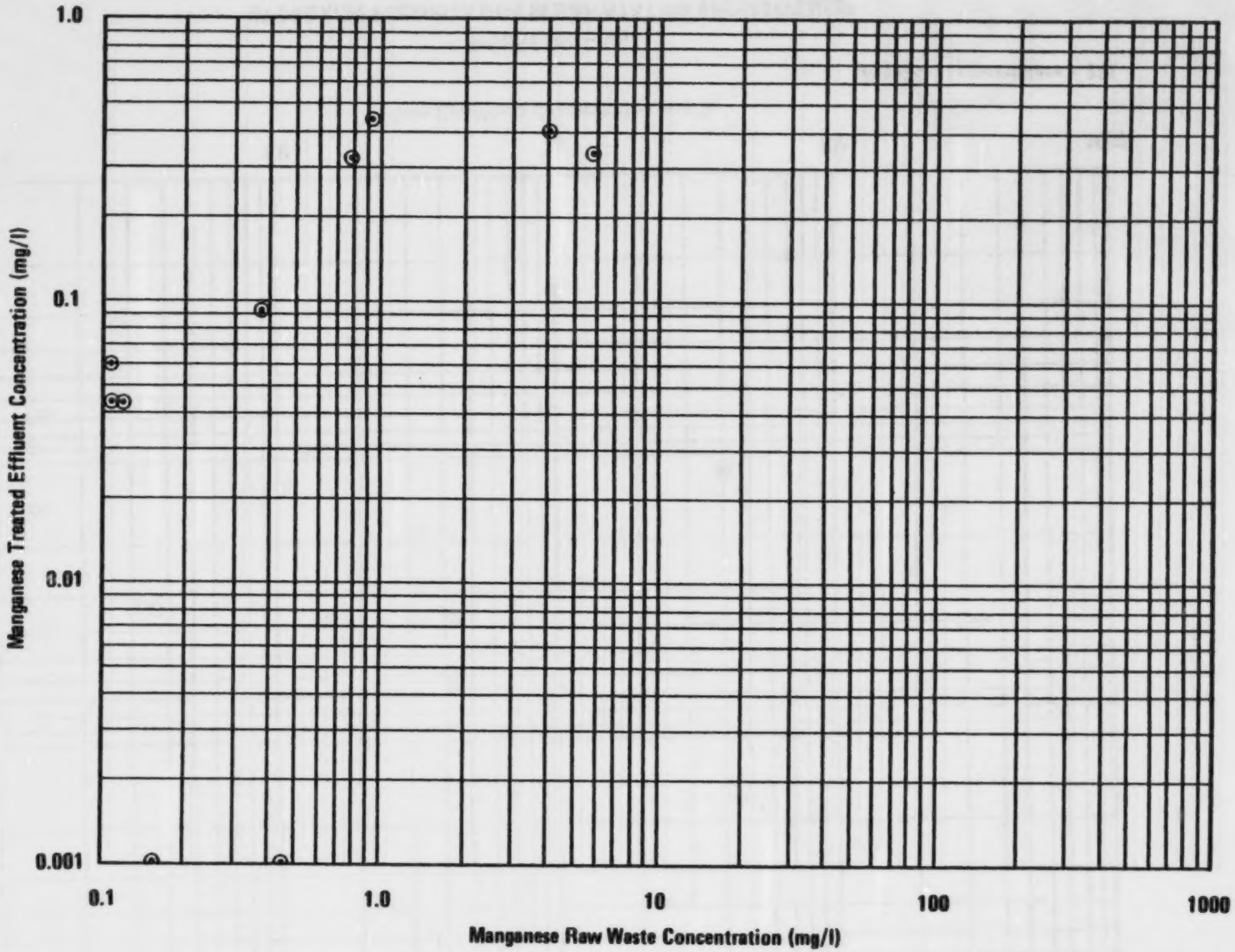
(Number of observations = 29)

FIGURE VII – 9
HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
ZINC



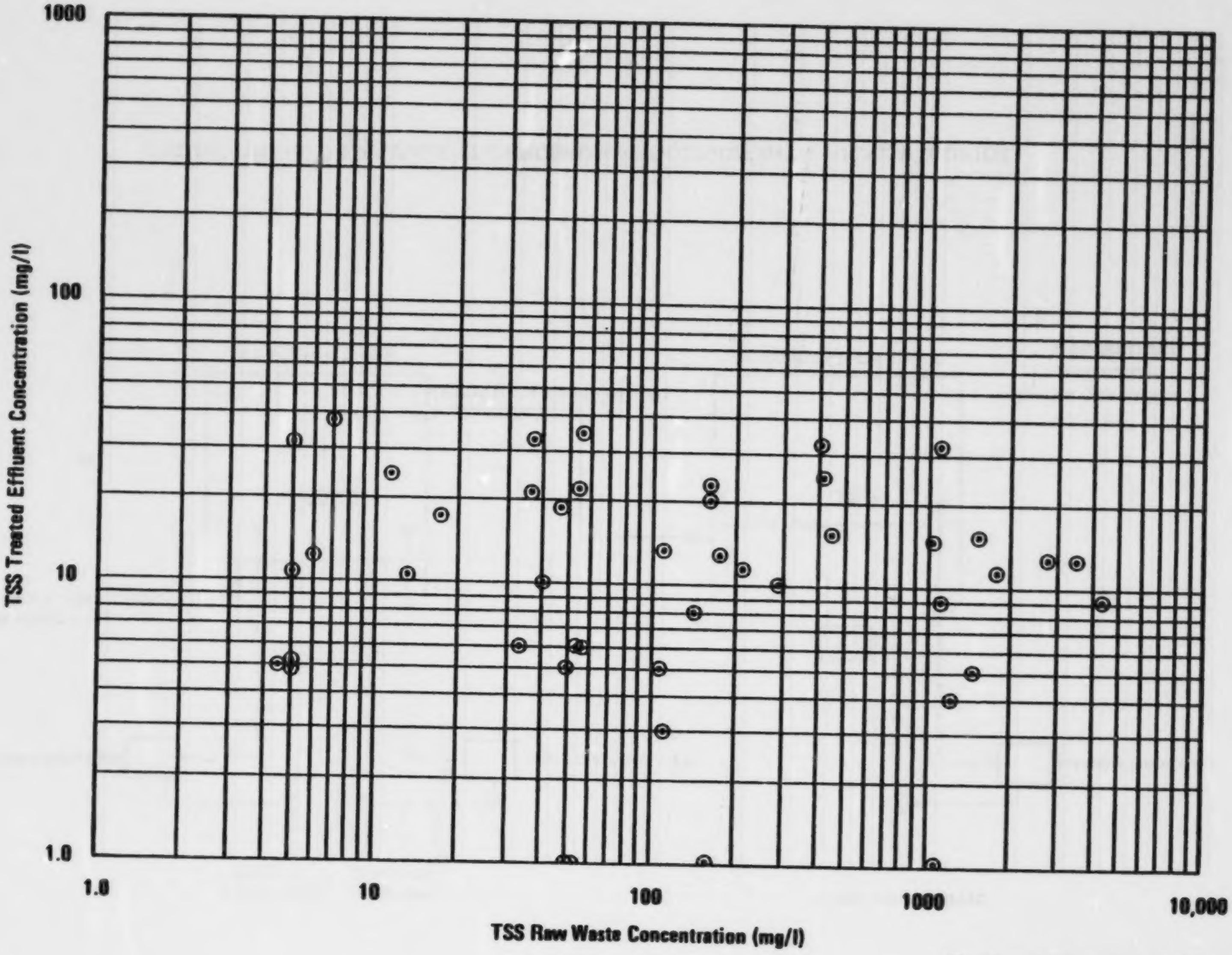
(Number of observations = 29)

FIGURE VII–10
HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
IRON



(Number of observations = 10)

FIGURE VII–11
HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
MANGANESE



(Number of observations = 46)

FIGURE VII– 12
HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
TSS

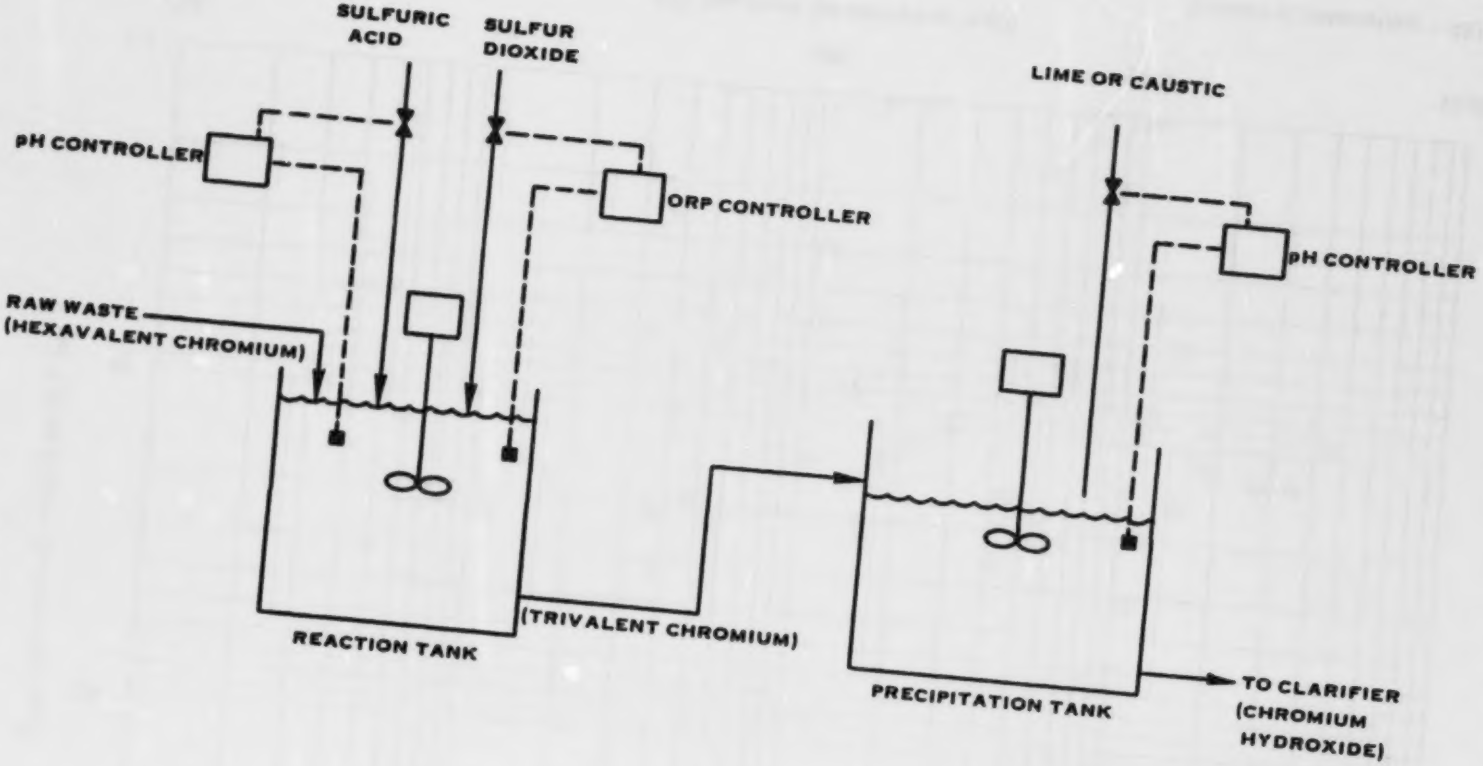

SULFURIC ACID
SULFUR DIOXIDE
pH CONTROLLER
ORP CONTROLLER
RAW WASTE (HEXAVALENT CHROMIUM)
REACTION TANK
(TRIVALENT CHROMIUM)
LIME OR CAUSTIC
pH CONTROLLER
PRECIPITATION TANK
TO CLARIFIER (CHROMIUM HYDROXIDE)

FIGURE VII-13. HEXAVALENT CHROMIUM REDUCTION WITH SULFUR DIOXIDE

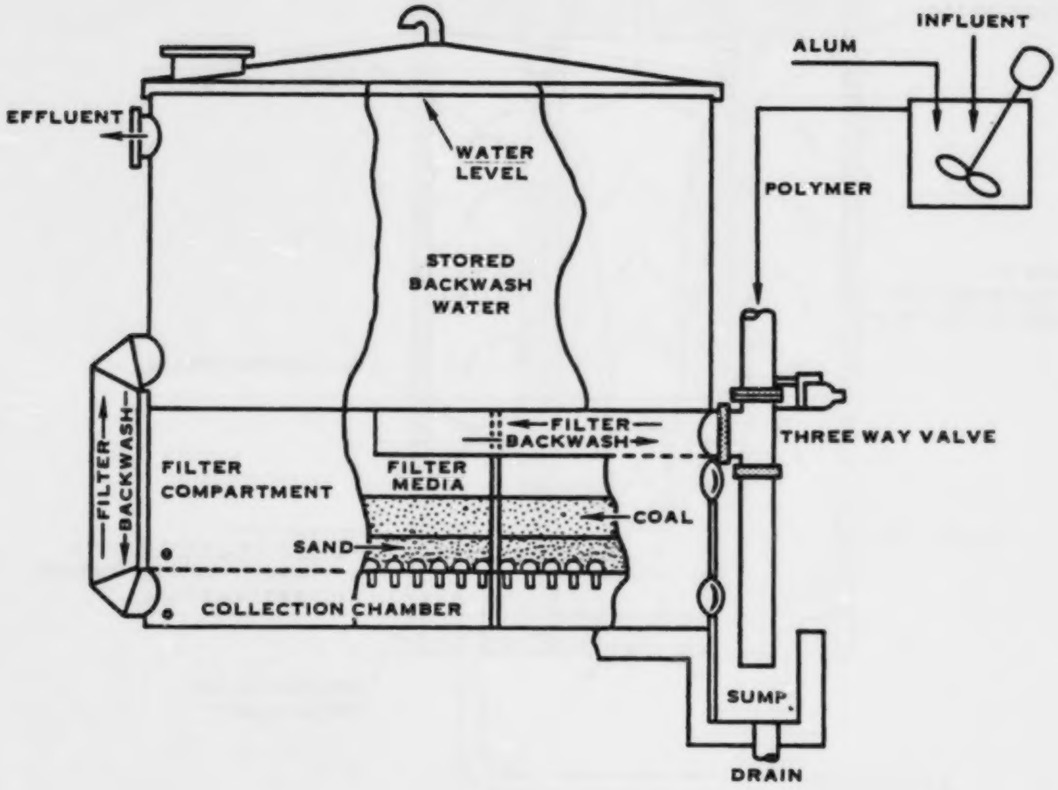
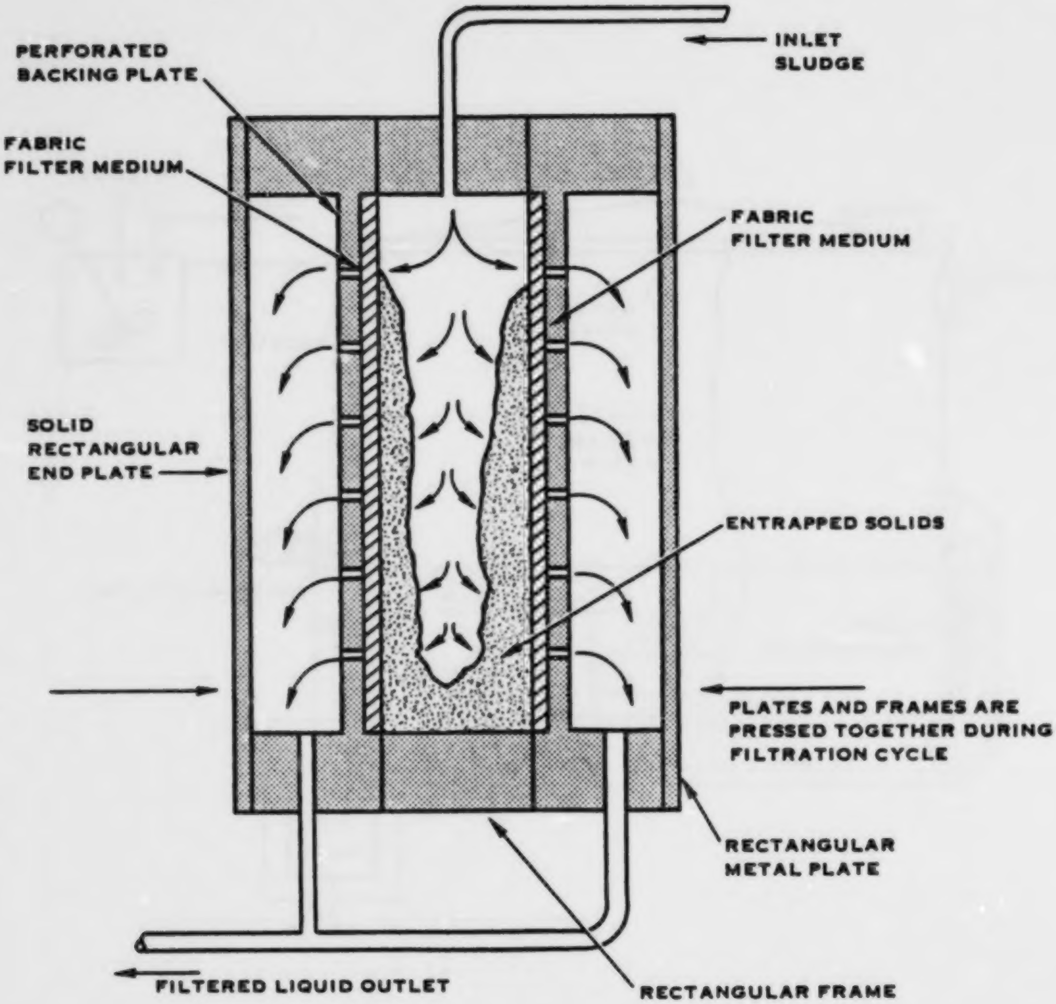

INFLUENT
ALUM
EFFLUENT
WATER LEVEL
POLYMER
STORED BACKWASH WATER
FILTER
BACKWASH
THREE WAY VALVE
FILTER COMPARTMENT
FILTER MEDIA
COAL
SAND
COLLECTION CHAMBER
SUMP
DRAIN

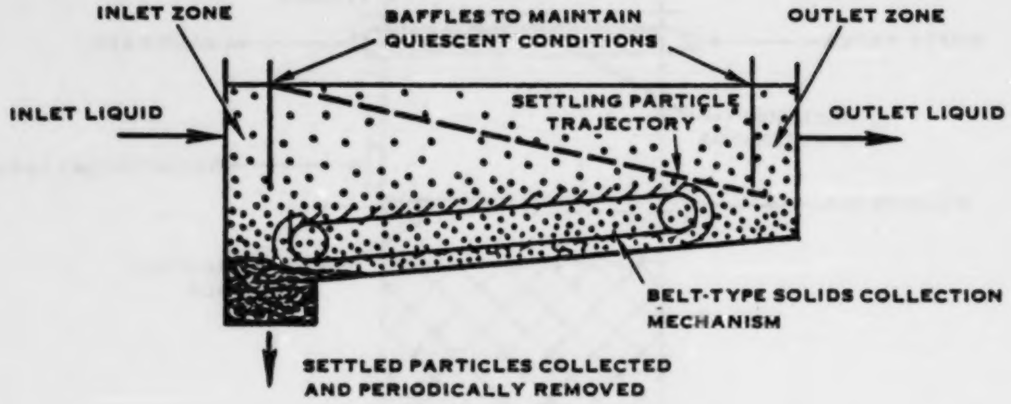
FIGURE VII-14. GRANULAR BED FILTRATION



PERFORATED BACKING PLATE
INLET SLUDGE
FABRIC FILTER MEDIUM
FABRIC FILTER MEDIUM
SOLID RECTANGULAR END PLATE
ENTRAPPED SOLIDS
PLATES AND FRAMES ARE PRESSED TOGETHER DURING FILTRATION CYCLE
RECTANGULAR METAL PLATE
FILTERED LIQUID OUTLET
RECTANGULAR FRAME

FIGURE VII-15. PRESSURE FILTRATION

SEDIMENTATION BASIN


INLET ZONE
BAFFLES TO MAINTAIN QUIESCENT CONDITIONS
OUTLET ZONE
INLET LIQUID
SETTLING PARTICLE TRAJECTORY
OUTLET LIQUID
BELT-TYPE SOLIDS COLLECTION MECHANISM
SETTLED PARTICLES COLLECTED AND PERIODICALLY REMOVED

CIRCULAR CLARIFIER

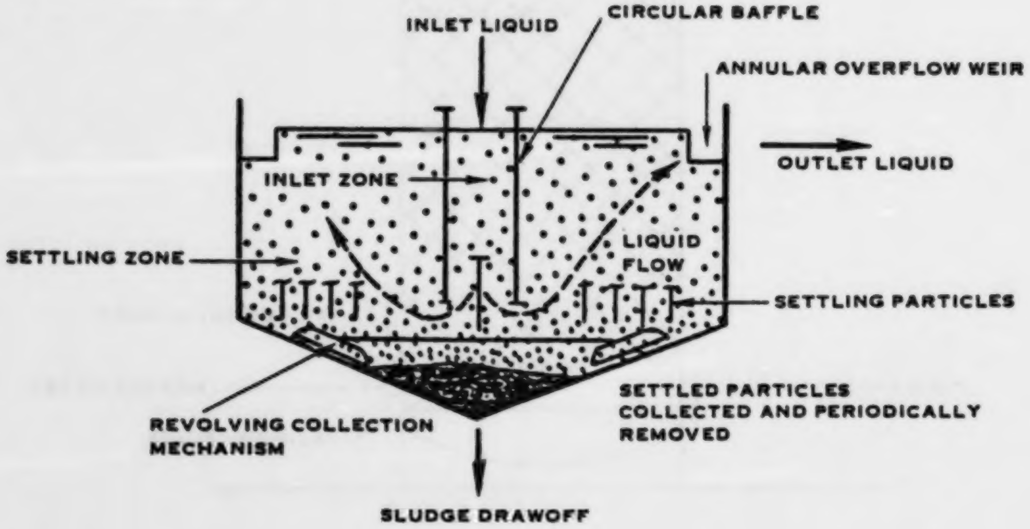

INLET LIQUID
CIRCULAR BAFFLE
ANNULAR OVERFLOW WEIR
OUTLET LIQUID
INLET ZONE
LIQUID FLOW
SETTLING ZONE
SETTLING PARTICLES
SETTLED PARTICLES COLLECTED AND PERIODICALLY REMOVED
REVOLVING COLLECTION MECHANISM
SLUDGE DRAWOFF

FIGURE VII-16. REPRESENTATIVE TYPES OF SEDIMENTATION

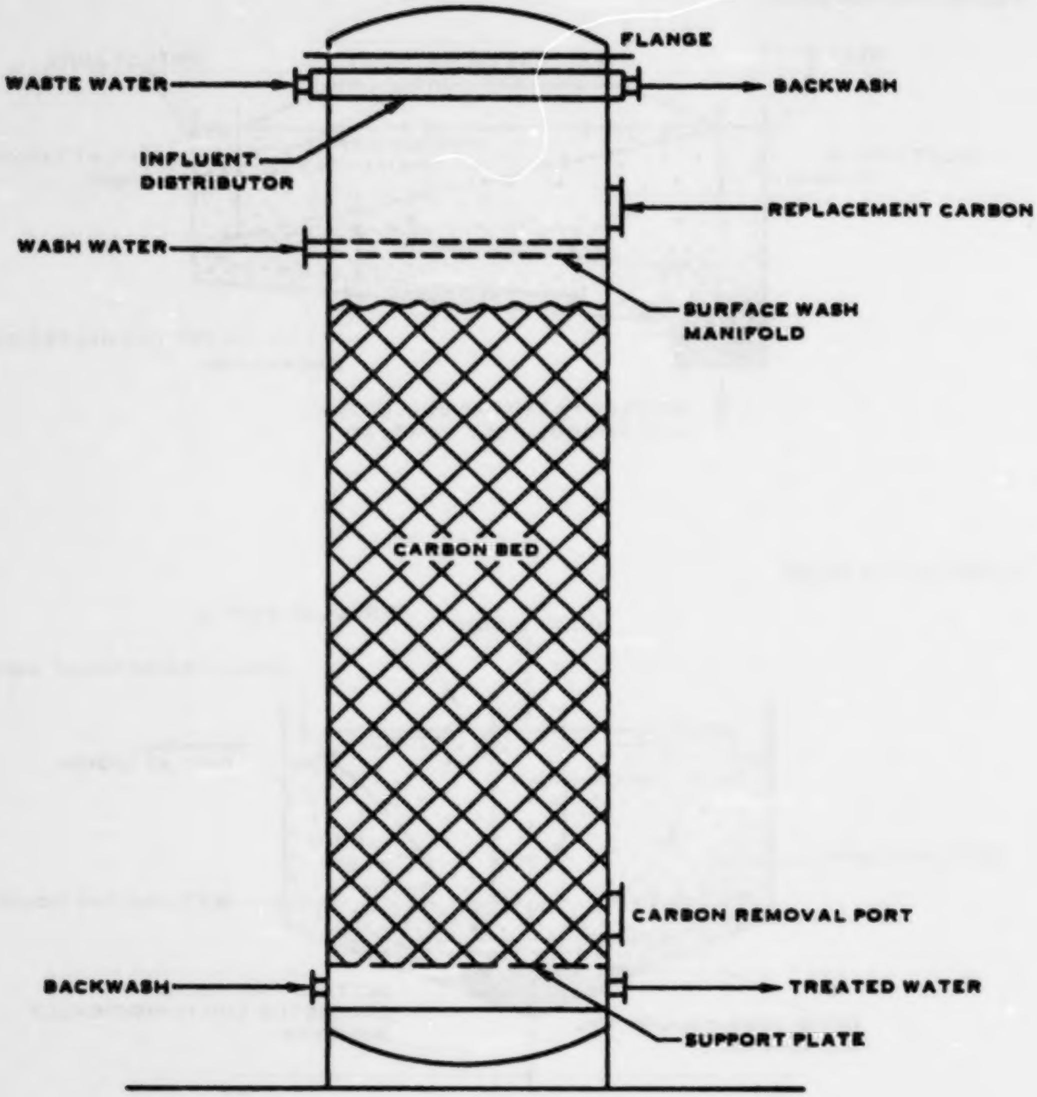

FLANGE
WASTE WATER
BACKWASH
INFLUENT DISTRIBUTOR
REPLACEMENT CARBON
WASH WATER
SURFACE WASH MANIFOLD
CARBON BED
CARBON REMOVAL PORT
BACKWASH
TREATED WATER
SUPPORT PLATE

FIGURE VII-17. ACTIVATED CARBON ADSORPTION COLUMN

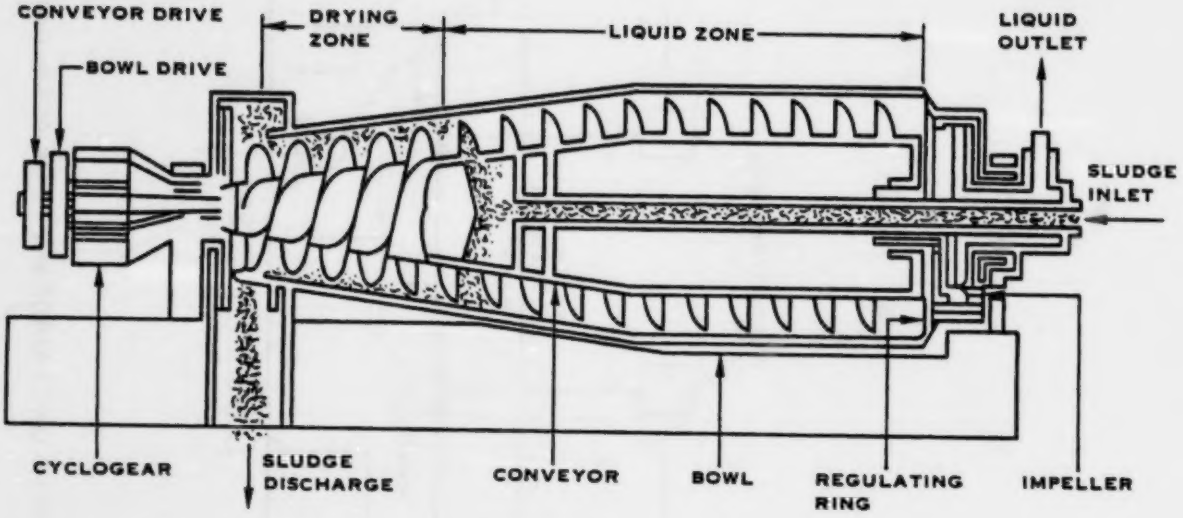

CONVEYOR DRIVE
BOWL DRIVE
DRYING ZONE
LIQUID ZONE
LIQUID OUTLET
SLUDGE INLET
CYCLOGEAR
SLUDGE DISCHARGE
CONVEYOR
BOWL
REGULATING RING
IMPELLER

FIGURE VII-18. CENTRIFUGATION

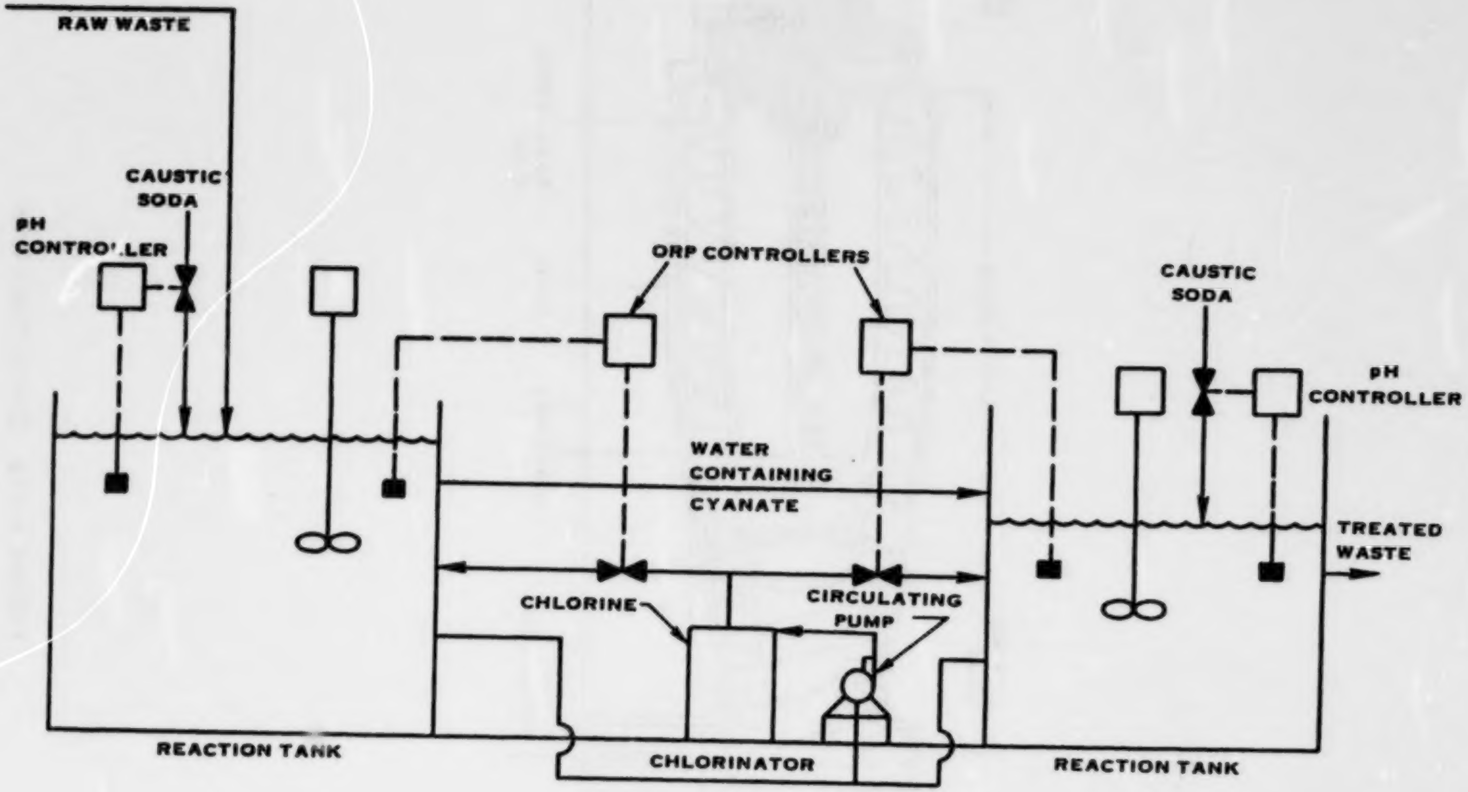

RAW WASTE
CAUSTIC SODA
pH CONTROLLER
ORP CONTROLLERS
CAUSTIC SODA
pH CONTROLLER
WATER CONTAINING CYANATE
TREATED WASTE
CHLORINE
CIRCULATING PUMP
REACTION TANK
CHLORINATOR
REACTION TANK

FIGURE VII-19. TREATMENT OF CYANIDE WASTE BY ALKALINE CHLORINATION

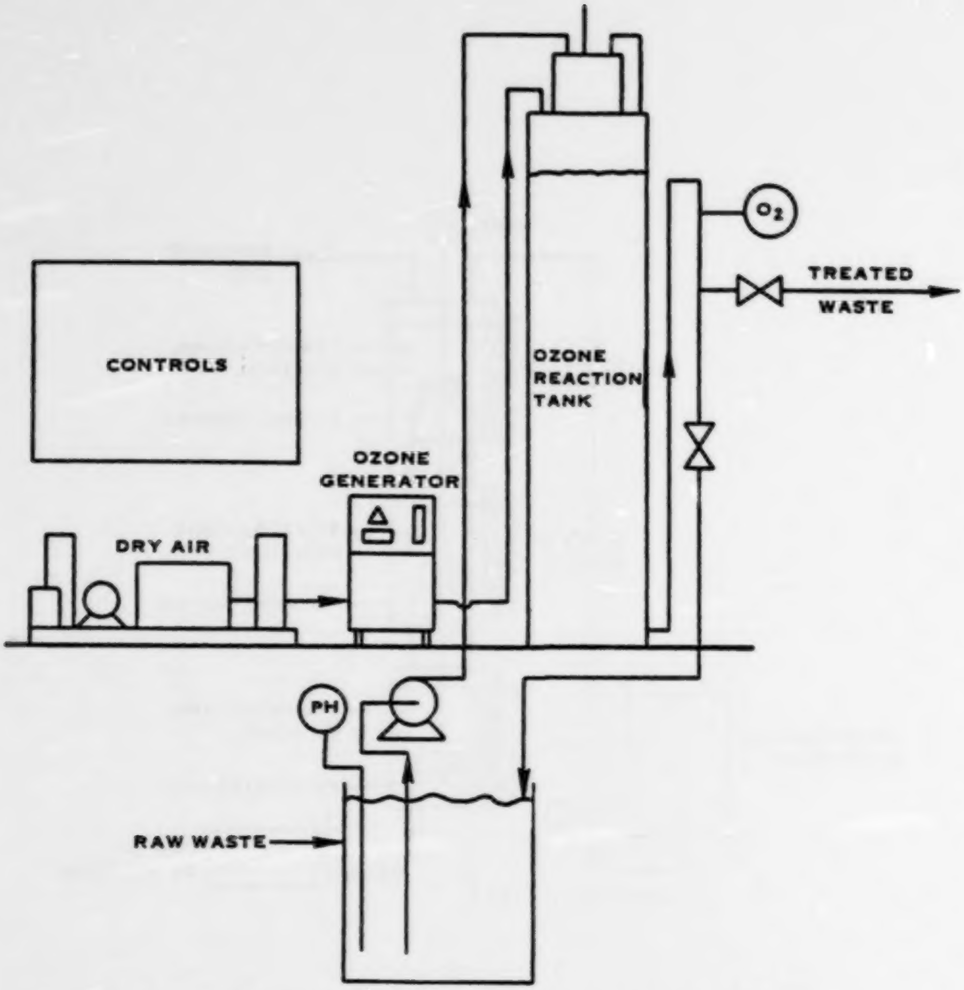

CONTROLS
OZONE GENERATOR
DRY AIR
OZONE REACTION TANK
O_2
TREATED WASTE
PH
RAW WASTE

FIGURE VII-20. TYPICAL OZONE PLANT FOR WASTE TREATMENT

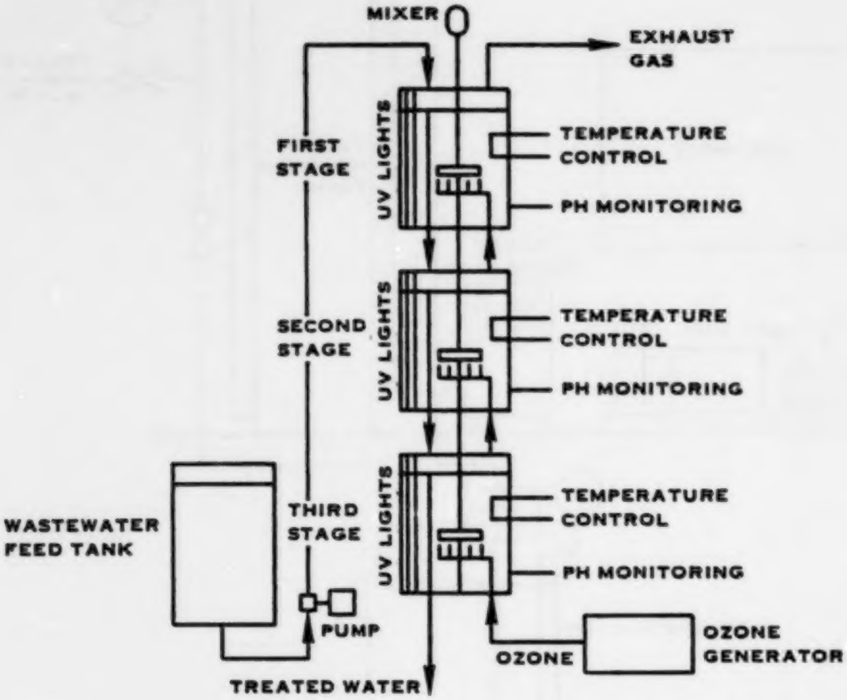
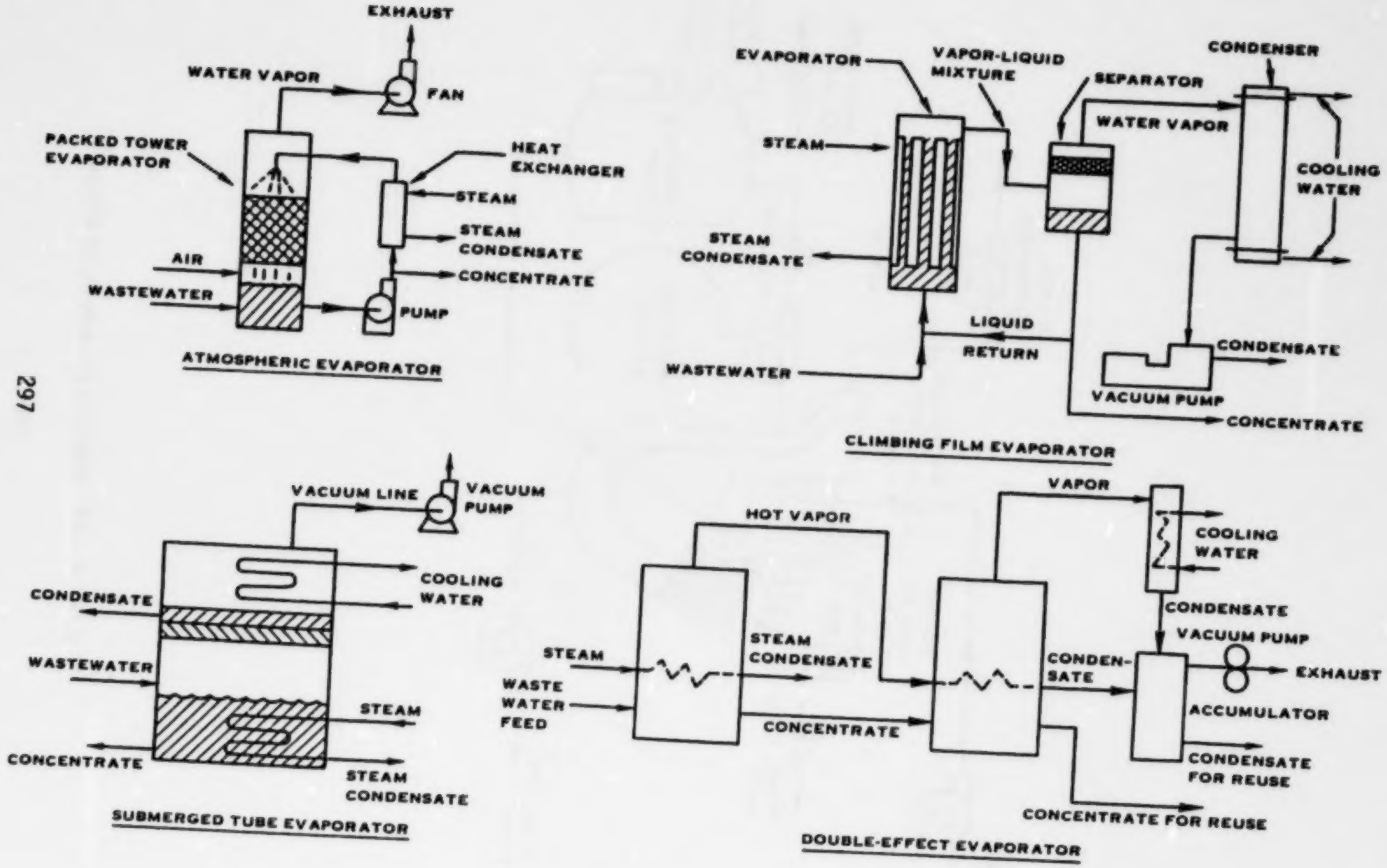

MIXER
EXHAUST GAS
FIRST STAGE
UV LIGHTS
TEMPERATURE CONTROL
PH MONITORING
SECOND STAGE
UV LIGHTS
TEMPERATURE CONTROL
PH MONITORING
THIRD STAGE
UV LIGHTS
TEMPERATURE CONTROL
PH MONITORING
WASTEWATER FEED TANK
PUMP
OZONE
OZONE GENERATOR
TREATED WATER

FIGURE VII-21. UV/OZONATION


EXHAUST
WATER VAPOR
FAN
PACKED TOWER EVAPORATOR
HEAT EXCHANGER
STEAM
STEAM CONDENSATE
CONCENTRATE
AIR
WASTEWATER
PUMP
EVAPORATOR
VAPOR-LIQUID MIXTURE
SEPARATOR
CONDENSER
WATER VAPOR
STEAM
COOLING WATER
STEAM CONDENSATE
LIQUID RETURN
CONDENSATE
WASTEWATER
VACUUM PUMP
CONCENTRATE
VACUUM LINE
VACUUM PUMP
COOLING WATER
CONDENSATE
WASTEWATER
STEAM
CONCENTRATE
STEAM CONDENSATE
VAPOR
HOT VAPOR
COOLING WATER
CONDENSATE
VACUUM PUMP
STEAM
STEAM CONDENSATE
CONDEN-SATE
EXHAUST
WASTE WATER FEED
CONCENTRATE
ACCUMULATOR
CONDENSATE FOR REUSE
CONCENTRATE FOR REUSE

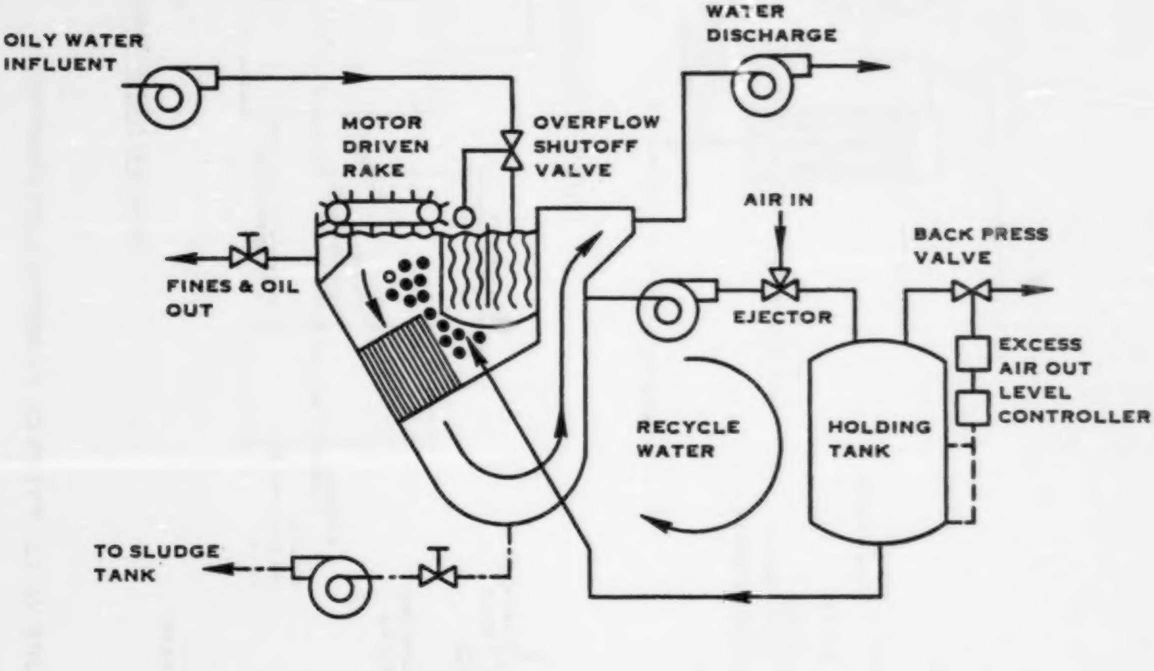
ATMOSPHERIC EVAPORATOR

CLIMBING FILM EVAPORATOR

SUBMERGED TUBE EVAPORATOR

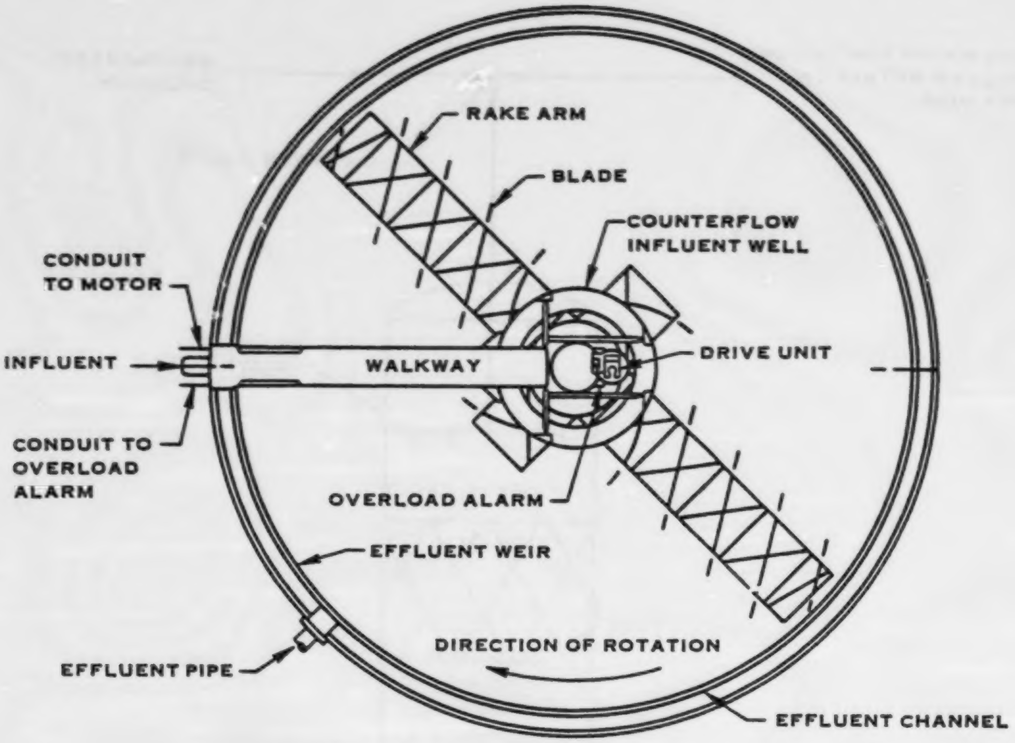
DOUBLE-EFFECT EVAPORATOR

FIGURE VII-22. TYPES OF EVAPORATION EQUIPMENT



OILY WATER INFLUENT
WATER DISCHARGE
MOTOR DRIVEN RAKE
OVERFLOW SHUTOFF VALVE
AIR IN
BACK PRESS VALVE
FINES & OIL OUT
EJECTOR
EXCESS AIR OUT
LEVEL CONTROLLER
RECYCLE WATER
HOLDING TANK
TO SLUDGE TANK

FIGURE VII-23. DISSOLVED AIR FLOTATION


RAKE ARM
BLADE
COUNTERFLOW INFLUENT WELL
CONDUIT TO MOTOR
INFLUENT
WALKWAY
DRIVE UNIT
CONDUIT TO OVERLOAD ALARM
OVERLOAD ALARM
EFFLUENT WEIR
DIRECTION OF ROTATION
EFFLUENT PIPE
EFFLUENT CHANNEL

PLAN

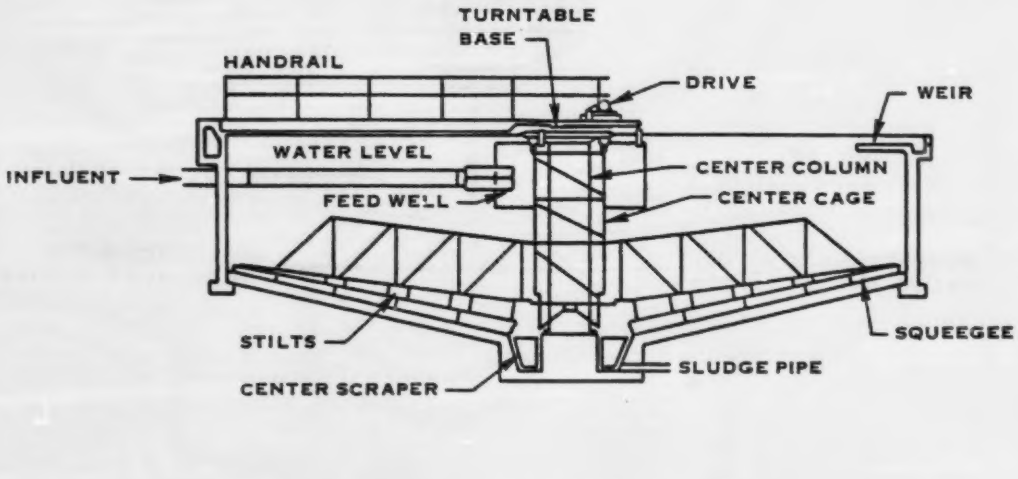

TURNTABLE BASE
HANDRAIL
DRIVE
WEIR
WATER LEVEL
INFLUENT
CENTER COLUMN
FEED WELL
CENTER CAGE
STILTS
SQUEEGEE
SLUDGE PIPE
CENTER SCRAPER

FIGURE VII-24. GRAVITY THICKENING

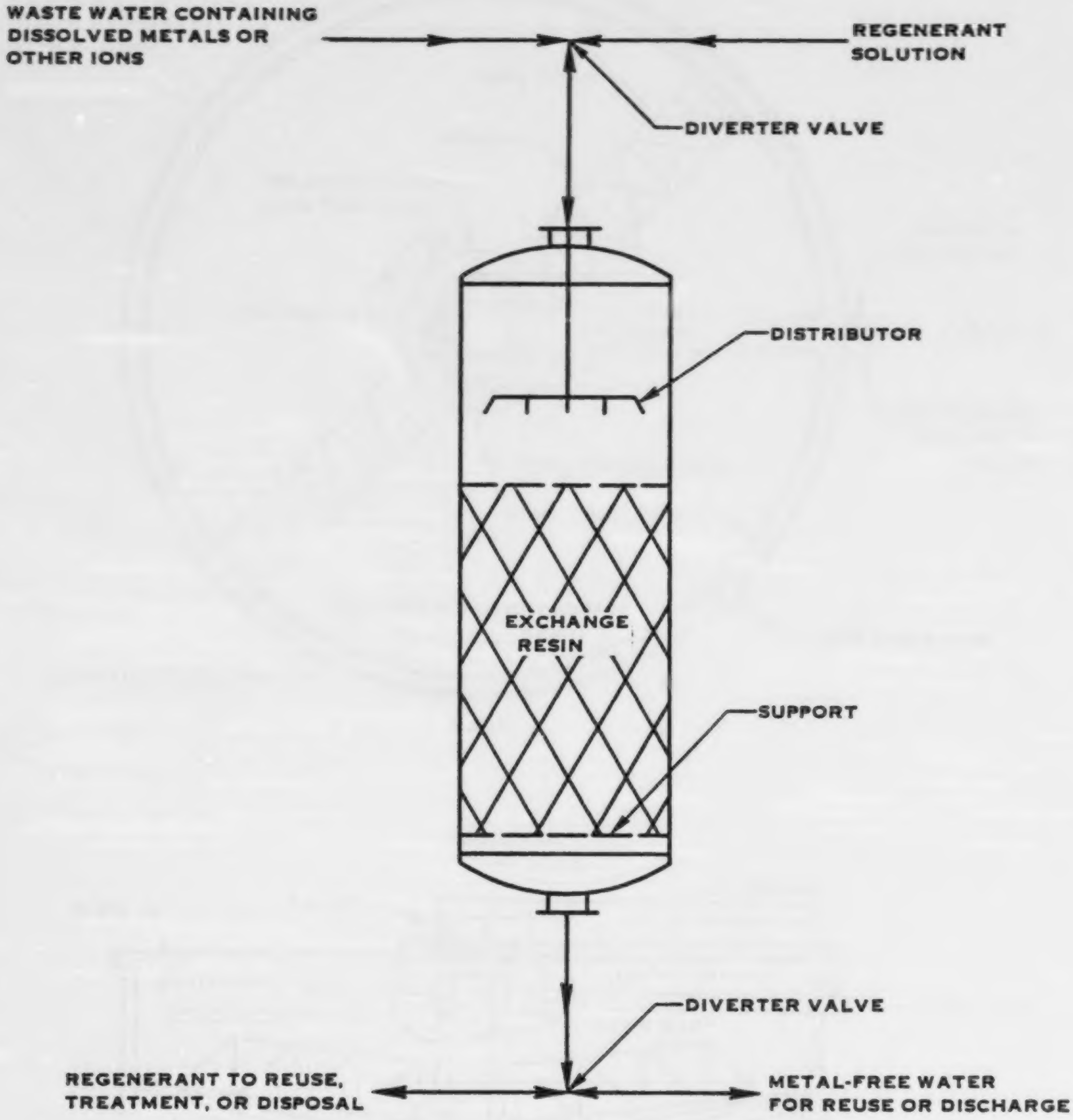

WASTE WATER CONTAINING DISSOLVED METALS OR OTHER IONS
REGENERANT SOLUTION
DIVERTER VALVE
DISTRIBUTOR
EXCHANGE RESIN
SUPPORT
DIVERTER VALVE
REGENERANT TO REUSE, TREATMENT, OR DISPOSAL
METAL-FREE WATER FOR REUSE OR DISCHARGE

FIGURE VII-25. ION EXCHANGE WITH REGENERATION

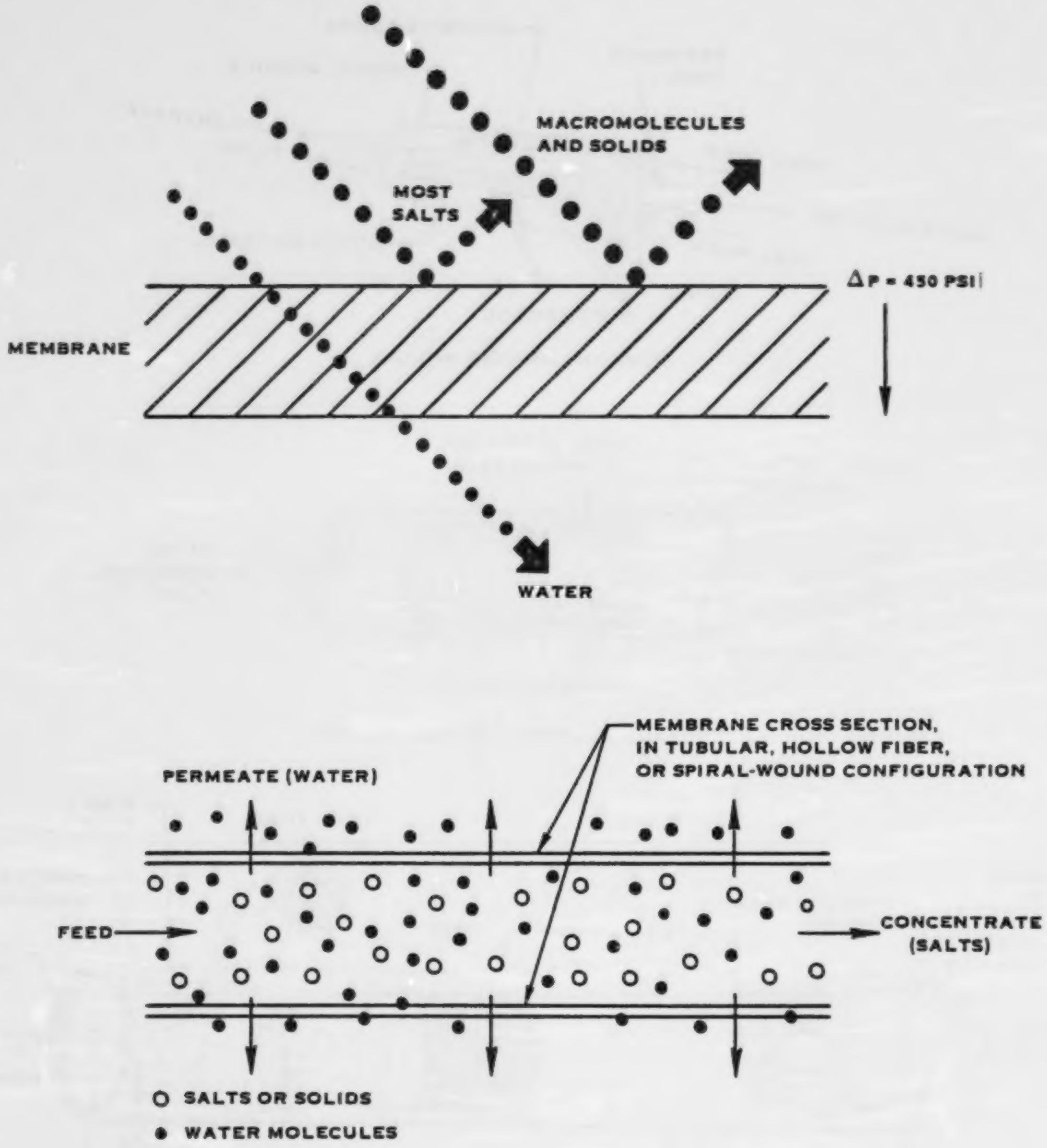
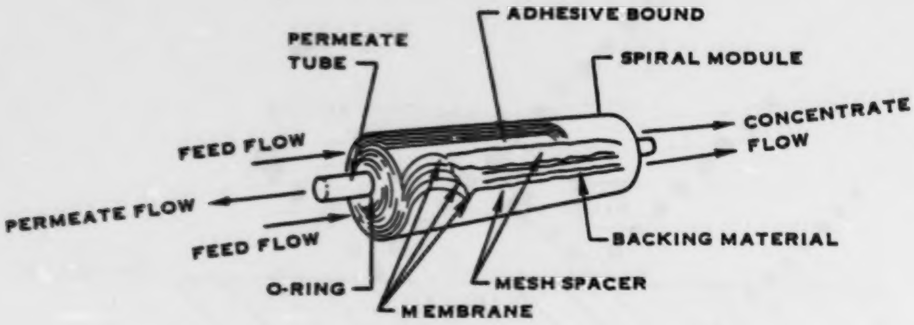
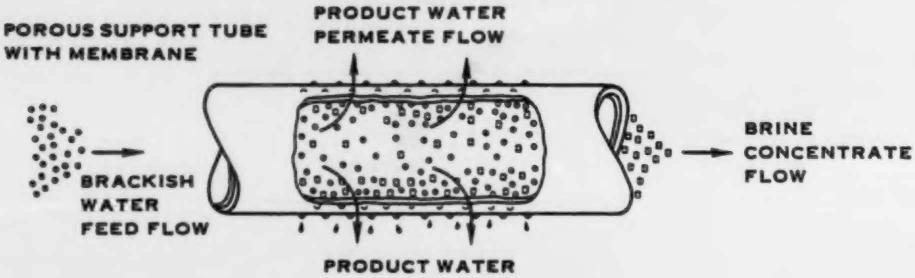

MACROMOLECULES AND SOLIDS
MOST SALTS
$\Delta P = 450$ PSI
MEMBRANE
WATER
MEMBRANE CROSS SECTION, IN TUBULAR, HOLLOW FIBER, OR SPIRAL-WOUND CONFIGURATION
PERMEATE (WATER)
FEED
CONCENTRATE (SALTS)
○ SALTS OR SOLIDS
● WATER MOLECULES

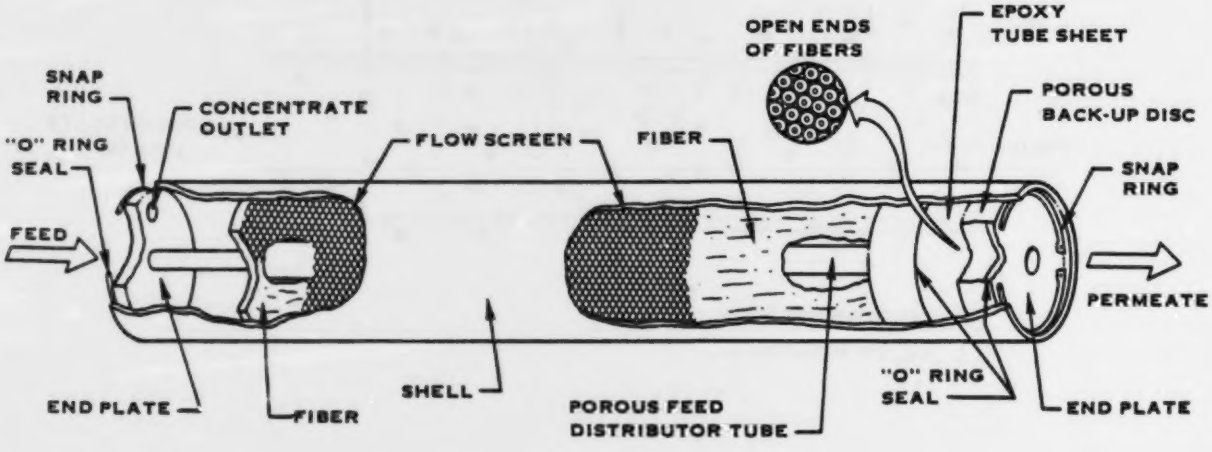
FIGURE VII-26. SIMPLIFIED REVERSE OSMOSIS SCHEMATIC


ADHESIVE BOUND
PERMEATE TUBE
SPIRAL MODULE
CONCENTRATE FLOW
FEED FLOW
PERMEATE FLOW
FEED FLOW
BACKING MATERIAL
O-RING
MESH SPACER
MEMBRANE

SPIRAL MEMBRANE MODULE


PRODUCT WATER PERMEATE FLOW
POROUS SUPPORT TUBE WITH MEMBRANE
BRINE CONCENTRATE FLOW
BRACKISH WATER FEED FLOW
PRODUCT WATER

TUBULAR REVERSE OSMOSIS MODULE


OPEN ENDS OF FIBERS
EPOXY TUBE SHEET
SNAP RING
CONCENTRATE OUTLET
POROUS BACK-UP DISC
"O" RING SEAL
FLOW SCREEN
FIBER
SNAP RING
FEED
PERMEATE
"O" RING SEAL
END PLATE
FIBER
SHELL
POROUS FEED DISTRIBUTOR TUBE
END PLATE

HOLLOW FIBER MODULE

FIGURE VII-27. REVERSE OSMOSIS MEMBRANE CONFIGURATIONS

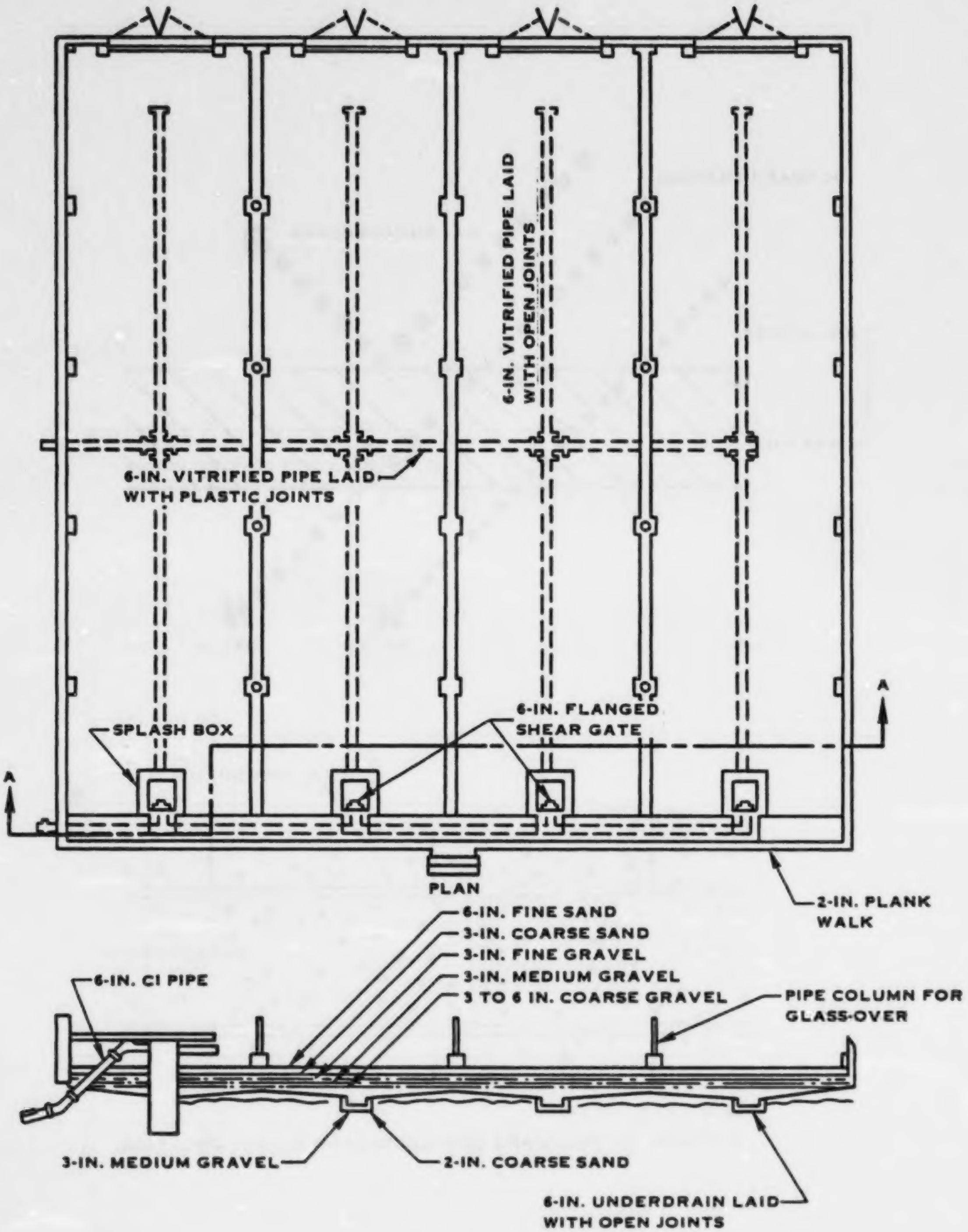

6-IN. VITRIFIED PIPE LAID WITH OPEN JOINTS
6-IN. VITRIFIED PIPE LAID WITH PLASTIC JOINTS
SPLASH BOX
6-IN. FLANGED SHEAR GATE
A
A
PLAN
2-IN. PLANK WALK
6-IN. FINE SAND
3-IN. COARSE SAND
3-IN. FINE GRAVEL
3-IN. MEDIUM GRAVEL
3 TO 6 IN. COARSE GRAVEL
6-IN. CI PIPE
PIPE COLUMN FOR GLASS-OVER
3-IN. MEDIUM GRAVEL
2-IN. COARSE SAND
6-IN. UNDERDRAIN LAID WITH OPEN JOINTS
SECTION A-A

FIGURE VII-28. SLUDGE DRYING BED

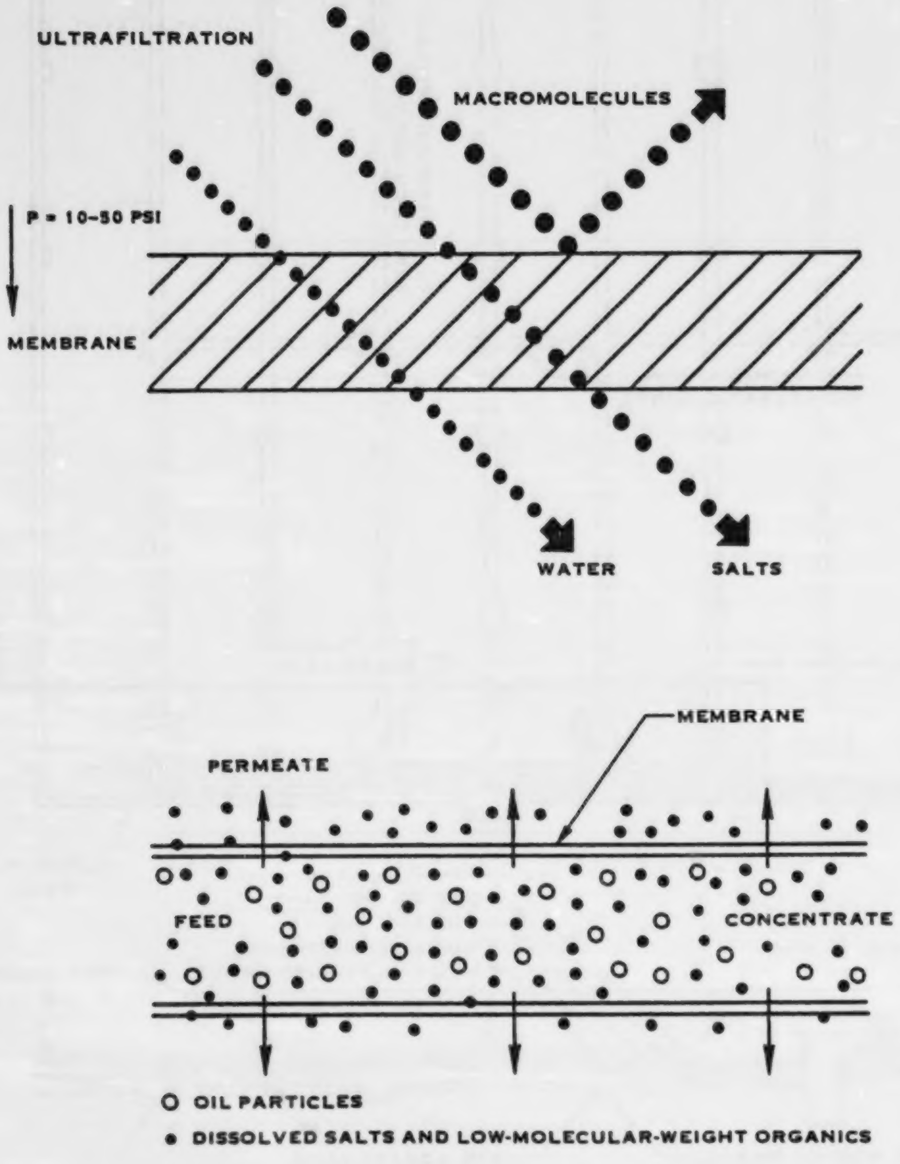

ULTRAFILTRATION
MACROMOLECULES
P = 10-50 PSI
MEMBRANE
WATER
SALTS
MEMBRANE
PERMEATE
FEED
CONCENTRATE
O OIL PARTICLES
● DISSOLVED SALTS AND LOW-MOLECULAR-WEIGHT ORGANICS

FIGURE VII-29. SIMPLIFIED ULTRAFILTRATION FLOW SCHEMATIC

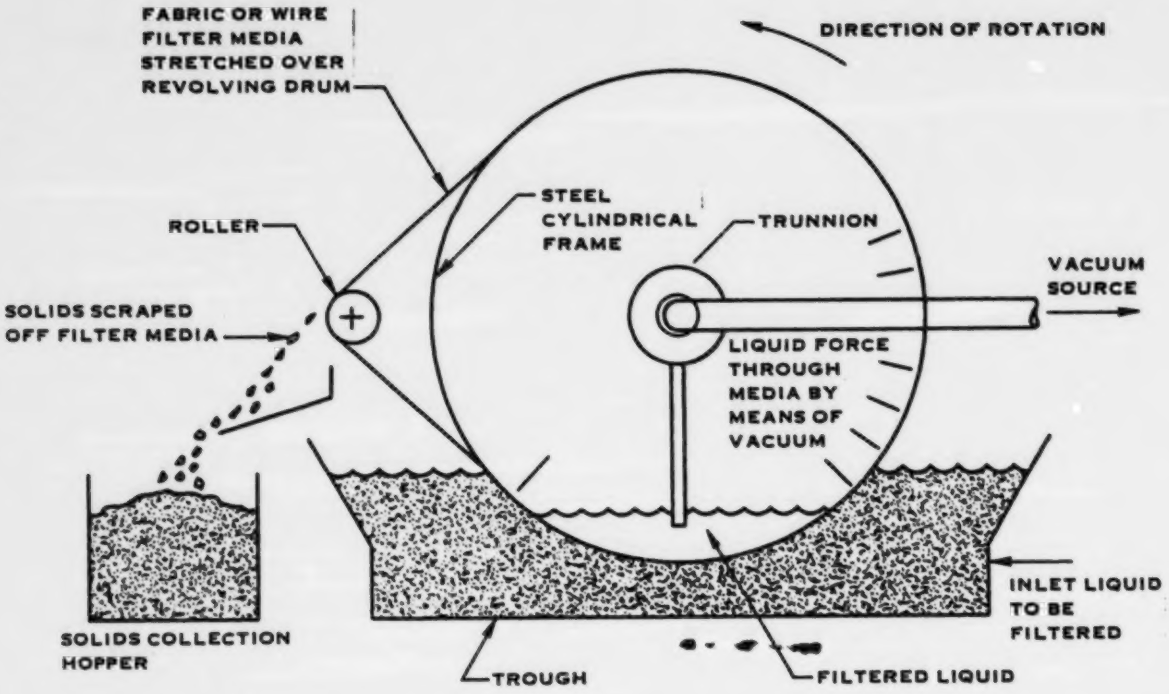

FABRIC OR WIRE FILTER MEDIA STRETCHED OVER REVOLVING DRUM
DIRECTION OF ROTATION
STEEL CYLINDRICAL FRAME
ROLLER
TRUNNION
VACUUM SOURCE
SOLIDS SCRAPED OFF FILTER MEDIA
LIQUID FORCE THROUGH MEDIA BY MEANS OF VACUUM
INLET LIQUID TO BE FILTERED
SOLIDS COLLECTION HOPPER
TROUGH
FILTERED LIQUID

FIGURE VII-30. VACUUM FILTRATION

SECTION VIII

COST OF WASTE WATER CONTROL AND TREATMENT

This section presents estimates of the costs of implementing the major wastewater treatment and control technologies descrived in Section VII. These cost estimates, together with the estimated pollutant reduction performance for each treatment and control option presented in Sections IX, X, XI, and XII provide a basis for evaluating the options presented and identification of the best practicable control technology currently available (BPT), best available technology economically achievable (BAT), best demonstrated technology (BDT), and the appropriate technology for pretreatment. The cost estimates also provide the basis for the determining the probable economic impact on the coil coating category of regulation at different pollutant discharge levels. In addition, this section addresses non-water quality environmental impacts of wastewater treatment and control alternatives, including air pollution, noise pollution, solid wastes, and energy requirements.

In developing the cost estimates presented in this section, EPA selected specific wastewater treatment technologies and in-process control techniques from among those discussed in Section VII and combined them in wastewater treatment and control systems appropriate for each subcategory. Investment and annual costs for each system were estimated based on wastewater flow rates and raw waste characteristics for each subcategory as presented in Section V.

COST ESTIMATION METHODOLOGY

Cost estimation is accomplished using a computer program which accepts inputs specifying the treatment system to be estimated, chemical characteristics of the raw waste streams treated, flow rates and operating schedules. The program accesses models for specific treatment components which relate component investment and operating costs, materials and energy requirements, and effluent stream characteristics to influent flow rates and stream characteristics. Component models are exercised sequentially as the components are encountered in the system to determine chemical characteristics and flow rates at each point. Component investment and annual costs are also determined and used in the computation of total system costs. Mass balance calculations are used to determine the characteristics of combined streams resulting from mixing two or more streams and to determine the volume of sludges or liquid wastes resulting from treatment operations such as sedimentation, filtration, flotation, and oil separation.

Cost estimates are broken down into several distinct elements: total investment and annual costs, operation and maintenance costs, energy costs, depreciation, and annual costs of capital. The cost estimation program incorporates provisions for adjustment of all costs to a common dollar base on the basis of economic indices appropriate to capital equipment and operating supplies. January 1978 dollar base has been used throughout this document as the basing point requiring least adjustment of the data supplied. Labor and electric power costs are input variables appropriate to the dollar base year for cost estimates.

Cost Estimation Input Data

The waste treatment system descriptions input to the computer cost estimation program include both a specification of the waste treatment components included and a definition of their interconnections. For some components, retention times or other operating parameters are specified in the input, while for others, such as reagent mix tanks and clarifiers, these parameters are specified within the program based on prevailing design practice in industrial waste treatment. The waste treatment system descriptions may include multiple raw waste stream inputs and multiple treatment trains. For example, cyanide bearing waste streams are segregated and treated by cyanide precipitation after chromium reduction and then given chemical precipitation treatment with the remaining process wastewater.

The specific treatment systems selected for cost estimation for each subcategory were based on an examination of raw waste characteristics, consideration of manufacturing processes, and an evaluation of available treatment technologies discussed in Section VII. The rationale for selection of these systems is presented in Sections IX through XII which also discusses their pollution removal effectiveness.

The input data set also includes chemical characteristics for each raw waste stream (specified as input to the treatment systems for which costs are to be estimated). These characteristics are derived from the raw waste sampling data presented in Section V. The pollutant parameters which are presently accepted as input by the cost estimation program appear in Table VIII-1 (page 340). The values of these parameters are used in determining materials consumption, sludge volumes, treatment component sizes and effluent characteristics. The list of input parameters is expanded periodically as additional pollutants are found to be significant in waste streams from industries under study and as additional treatment technology cost and performance data become available. For the coil coating category, individual subcategories commonly encompass a number of different waste streams which are present to varying degrees at different facilities. The raw waste characteristics shown as input to waste treatment represent a mix of these streams including all significant pollutants generated in the subcategory and do not correspond precisely to process wastewater at any existing facility. The process by which these raw wastes were defined is explained in Section V.

The final input data set comprises raw waste flow rates for each input stream for a "normal" plant in each subcategory. The "normal" plant is defined as a plant having the mean prediction level for the subcategory and equivalent flow and wastewater characteristics. The normal plant is used to indicate the encountered at existing facilities for each coil coating subcategory and to indicate the treatment costs which would be incurred in the implementation of each control and treatment option considered. In addition, data corresponding to the flow rates and equipment in place reported by each plant in the category were used to provide cost estimates for use in economic impact analysis.

System Cost Computation

Figure VIII-1 (page 359) presents a simplified flow chart of the computer cost estimation system. This is useful in conceptualization of the estimation of wastewater treatment and control costs from the input data described above. In the computation, raw waste characteristics and flow rates for the first case are used as input to the model for the first treatment technology specified in the system definition. This model is used to determine the size and cost of the component, materials and energy consumed in its operation, and the volume and characteristics of the stream(s) discharged from it. These stream characteristics are then used as input to the next component(s) encountered in the system definition. This procedure is continued until the complete system costs and the volume and characteristics of the final effluent stream(s) and sludge or concentrated oil wastes have been determined. In addition to treatment components, the system may include mixers in which two streams are combined, and splitters in which part of a stream is directed to another destination. These elements are handled by mass balance calculations and allow cost estimation for specific treatment of segregated process wastes such as oxidation of cyanide bearing wastes prior to combination with other process wastes for further treatment, and representation of partial recycle of wastewater.

As an example of this computation process, the sequence of calculations involved in the development of cost estimates for a simple treatment system including chemical precipitation, sedimentation, and sludge dewatering are described. Initially, input specifications for the treatment system are read to set up the sequence of computations. The subroutine addressing chemical precipitation and clarification is then accessed. The sizes of the mixing tank and clarification are calculated based on the raw waste flow rate to provide 45 minute retention in the mix tank and 4 hour retention with 15.0 gph/ft2 surface loading in the clarifier. Based on these sizes, investment and annual costs for labor, supplies for the mixing tank and clarifier including mixers, clarifier rakes and other directly related equipment are determined. Fixed investment costs are then added to account for sludge pumps, controls and reagent feed systems.

Based on the input raw waste concentrations and flow rates, the reagent additions (lime, alum, and polyelectrolyte) are calculated to provide fixed concentrations of alum and polyelectrolyte and 10 percent excess lime over that required for stoichiometric reaction with the acidity and metals present in the waste stream. Costs are calculated for these materials, and the suspended solids and flow leaving the mixing tank and entering the clarifier are increased to reflect the lime solids added and precipitates formed. These modified stream characteristics are then used with performance algorithms for the clarifier (as discussed in Section VII) to determine concentrations of each pollutant in the clarifier effluent stream. By mass balance, the amount of each pollutant in the clarifier sludge may be determined. The volume of the sludge stream is determined by the concentration of TSS, which is fixed at 4 to 5 percent based on general operating experience; concentrations of other pollutants in the sludge stream are determined from their masses and the volume of the stream.

The subroutine describing vacuum filtration is then called, and the mass of suspended solids in the clarifier sludge stream is used to determine the size and investment cost of the vacuum filtration unit. Operating hours for the filter are calculated from the flow rate and TSS concentration and are used to determine manhours required for operation. Maintenance labor requirements are added as a fixed additional cost.

The sludge flow rate and TSS content are then used to determine costs of materials and supplies for vacuum filter operation including iron and alum added as filter aids, and the electrical power costs for operation. Finally, the vacuum filter performance algorithms are used to determine the volume and characteristics of the vacuum filter sludge and filtrate, and the costs of contract disposal of the sludge are calculated. The recycle of vacuum filter filtrate to the chemical precipitation-clarification system is not reflected in the calculations due to the difficulty of iterative solution of such loops and the general observation that the contributions of such streams to the total flow and pollutant levels are in practice, negligibly small. Such minor contributions are accounted for in the 20 percent excess capacity provided in most components.

The costs determined for all components of the system are summed and subsidiary costs are added to provide output specifying total investment and annual costs for the system and annual costs for capital, depreciation, operation and maintenance, and energy. Costs for specific system components and the characteristics of all streams in the system may also be specified as output from the program.

After proposal numerous public comments were received about the Agency's porcelain enameling costs and costing factors. Because the same methodology and costing factors were proposed for both coil coating and porcelain enameling, the Agency considered comments about porcelain enameling costs to be equally valid for coil coating. Review of data and consideration of information provided in the comments resulted in a number of changes that increased substantially the Agency's cost estimates. These changes are summarized here.

1. The hydraulic surface loading of clarifier was reduced from 33.3 to 15.0 gal/hr/ft^2.

2. The TSS concentration in clarifier sludge stream was corrected to read 4.5 percent.

3. The excess capacity factor for flocculator, settling tanks, and sludge pumps of clarifier was increased from 1.2 to 1.4.

4. Intercomponent piping, instrumentation, and contingency costs were added to list of subsidiary costs.

5. The wastewater sampling frequency chart was corrected to show weekly rather than monthly sampling at the third size level (189, 251-378, 500 lb/day).

6. Instrumentation costs are now assigned a fixed value of $25,000 for continuous treatment, zero cost for batch treatment.

7. Engineering costs were increased and now range from 10.6 percent of total investment for a $650,000 plant to 22 percent for a $55,000 plant.

8. Legal, fiscal, and administrative costs were increased and now range from 1.6 percent of total plant investment costs for a $650,000 plant, to 3.7 percent for a $55,000 plant.

9. Interest for construction costs was increased from 10 percent to 16 percent.

Treatment Component Models

The cost estimation program presently incorporates subroutines providing cost and performance calculations for the treatment technologies identified in Section VII. These subroutines have been developed over a period of years from the best available information, including on-site observations of treatment system performance, costs and construction practices at a large number of industrial facilities, published data, and information obtained from suppliers of wastewater treatment equipment. The subroutines are modified and new subroutines added as improvements in treatment technologies become available, and as additional treatment technologies are required for the industrial wastewater streams under study. Specific discussion of each of the treatment component models used in costing wastewater treatment and control systems for the coil coating category is presented later in this section where cost estimation is addressed, and in Section VII where performance aspects were developed.

In general terms, cost estimation is provided by mathematical relationships in each subroutine approximating observed correlations between component costs and the most significant operational parameters such as water flow rate, retention times, and pollutant concentrations. In general, flow rate is the primary determinant of investment costs and of most annual costs with the exception of materials costs. In some cases, however, as discussed for the vacuum filter, pollutant concentrations may also significantly influence costs.

Cost Factors and Adjustments

As previously indicated, costs are adjusted to a common dollar base and are generally influenced by a number of factors including: Cost of Labor, Cost of Energy, Capital Recovery Costs and Debt-Equity Ratio. These cost adjustments and factors are discussed below.

Dollar Base - A dollar base of January 1978 was used for all costs.

Investment Cost Adjustment - Investment costs were adjusted to the aforementioned dollar base by use of the Sewage Treatment Plant Construction Cost Index. This cost is published monthly by the EPA Division of Facilities Construction and Operation. The national average of the Construction Cost Index for January 1978 was 288.0.

Supply Cost Adjustment - Supply costs such as chemicals were related to the dollar base by the Wholesale Price Index. This figure was obtained from the U.S. Department of Labor, Bureau of Labor Statistics, "Monthly Labor Review". For January 1978 the "Industrial Commodities" Wholesale Price Index was 201.6. Process supply and replacement costs were included in the estimate of the total process operating and maintenance cost.

Cost of Labor - To relate the operating and maintenance labor costs, the hourly wage rate for non-supervisory workers in water, stream, and sanitary systems was used from the U.S. Department of Labor, Bureau of Labor Statistics Monthly publication, "Employment and Earnings". For January 1978, this wage rate was $6.00 per hour. This wage rate was then applied to estimates of operation and maintenance man-hours within each process to obtain direct labor charges. To account for indirect labor charges, 15 percent of the direct labor costs was added to the direct labor charge to yield estimated total labor costs. Such items as Social Security, employer contributions to pension or retirement funds, and employer-paid premiums to various forms of insurance programs were considered indirect labor costs.

Cost of Energy - Energy requirements were calculated directly within each process. Estimated costs were then determined by applying an electrical rate of 3.3 cents per kilowatt hour.

The electrical charge for January 1978 was corroborated through consultation with the Energy Consulting Services Department of the Connecticut Light and Power Company. This electrical charge was determined by assuming that any electrical needs of a waste treatment facility or in-process technology would be satisfied by an existing electrical distribution system; i.e., no new meter would be required. This eliminated the formation of any new demand load base for the electrical charge.

Capital Recovery Costs - Capital recovery costs were divided into straight line ten-year depreciation and cost of capital at a ten percent annual interest rate for a period of ten years. The ten year depreciation period was consistent with the faster write-off (financial life) allowed for these facilities, even though the equipment life is in the range of 20 to 25 years. The annual cost of capital was calculated by using the capital recovery factor approach.

The capital recovery factor is normally used in industry to help allocate the initial investment and the interest to the total operating cost of the facility. It is equal to:

$$CRF = i + \frac{i}{(1+i)^N-1}$$

where i is the annual interest rate and N is the number of years over which the capital is to be recovered. The annual capital recovery was obtained by multiplying the initial investment by the capital recovery factor. The annual depreciation of the capital investment was calculated by dividing the initial investment by the depreciation period N, which was assumed to be ten years. The annual cost of capital was then equal to the annual capital recovery minus the depreciation.

Debt-Equity Ratio - Limitations on new borrowings assume that debt may not exceed a set percentage of the shareholders equity. This defines the breakdown of the capital investment between debt and equity charges. However, due to the lack of information about the financial status of various plants, it was not feasible to estimate typical shareholders equity to obtain debt financing limitations. For these reasons, no attempt was made to break down the capital cost into debt and equity charges. Rather, the annual cost of capital was calculated via the procedure outlined in the Capital Recovery Costs section above.

Subsidiary Costs

The waste treatment and control system costs for end-of-pipe and in-process waste water control and treatment systems include subsidiary costs associated with system construction and operation. These subsidiary costs include:

- administration and laboratory facilities
- garage and shop facilities
- line segregation
- yardwork
- land

- engineering
- legal, fiscal, and administrative
- interest during construction
- contingency
- intercomponent piping instrumentation

Administrative and laboratory facility treatment investment is the cost of constructing space for administration, laboratory, and service functions for the waste water treatment system. For these cost computations, it was assumed that there was already an existing building and space for administration, laboratory, and service functions. Therefore, there was no investment cost for this item.

For laboratory operations, an analytical fee of $90 (January 1978 dollars) was allowed for each wastewater sample, regardless of whether the laboratory work was done on or off site. This analytical fee is typical of the charges experienced during the past several years of sampling programs. The frequency of wastewater sampling is a function of wastewater discharge flow and is presented in Table VIII-2 (page 341). This frequency was suggested by the Water Compliance Division of the USEPA.

Industrial waste treatment facilities were assumed to need no garage and shop investment because this cost item was assumed to be part of the normal plant costs.

Line segregation investment costs account for plant modifications to segregate wastes. The investment costs for line segregation included placing a trench in the existing plant floor and installing the lines in this trench. The same trench was used for all pipes and a gravity feed to the treatment system was assumed. The pipe was assumed to run from the center of the floor to a corner. A rate of 2.04 liters per hour of waste water discharge per square meter of area (0.05 gallons per hour per square foot) was used to estimate floor and trench dimensions from waste water flow rates for use in this cost estimation process.

The yardwork investment cost item includes the cost of general site clearing, intercomponent piping, valves, overhead and underground electrical wiring, cable, lighting, control structures, manholes, tunnels, conduits, and general site items outside the structural confines of particular individual plant components. This cost is typically 9 to 18 percent of the installed components investment costs. These cost estimates, were based on an average of 14 percent. Annual yardwork operation and maintenance costs are considered a part of normal plant maintenance and were not included in these cost estimates.

No new land purchases were required. It was assumed that the land required for the end-of-pipe treatment system was already available at the plant.

Engineering costs include both basic and special services. Basic services include preliminary design reports, detailed design, and certain office and field engineering services during construction of projects. Special services include improvement studies, resident engineering, soils investigations, land surveys, operation and maintenance manuals, and other miscellaneous services. Engineering cost is a function of process installed and yardwork investment costs and ranges between 5.7 and 14 percent depending on the total of these costs.

Legal, fiscal and administrative costs relate to the planning and construction of waste water treatment facilities and include such items as preparation of legal documents, preparation of construction contracts, acquisition to land, etc. These costs are a function of process installed, yardwork, engineering, and land investment costs ranging between 1 and 3 percent of the total of these costs.

Interest cost during construction is the interest cost accrued on funds from the time payment is made to the contractor to the end of the construction period. The total of all other project investment costs (process installed; yardwork; land; engineering; and legal, fiscal, and administrative) and the applied interest affect this cost. An interest rate of 10 percent was used to determine the interest cost for these estimates. In general, interest cost during construction varies between 3 and 10 percent of total system costs.

Contingency allowance has been included at 10 percent and intercomponent piping at 20 percent of installed component cost; instrumentation is included as a lump sum of $25,000 for continuous processes only.

COST ESTIMATES FOR INDIVIDUAL TREATMENT TECHNOLOGIES

Introduction

Treatment technologies have been selected from among the larger set of available alternatives discussed in Section VII on the basis of an evaluation of raw waste characteristics, typical plant characteristics (e.g. location, production schedules, product mix, and land availability), and present treatment practices within the subcategories addressed. Specific rationale for selection is addressed in Sections IX, X, XI and XII. Cost estimates for each technology addressed in this section include investment costs and annual costs for depreciation, capital, operation and maintenance, and energy.

Investment - Investment is the capital expenditure required to bring the technology into operation. If the installation is a package contract, the investment is the purchase price of the installed equipment. Otherwise, it includes the equipment cost, cost of freight, insurance and taxes, and installation costs.

Total Annual Cost - Total annual cost is the sum of annual costs for depreciation, capital, operation and maintenance (less energy), and energy (as a separate function).

Depreciation - Depreciation is an allowance, based on tax regulations, for the recovery of fixed capital from an investment to be considered as a non-cash annual expense. It may be regarded as the decline in value of a capital asset due to wearout and obsolescence.

Capital - The annual cost of capital is the cost, to the plant, of obtaining capital expressed as an interest rate. It is equal to the capital recovery cost (as previously discussed on cost factors) less depreciation.

Operation and Maintenance - Operation and maintenance cost is the annual cost of running the waste water treatment equipment. It includes labor and materials such as waste treatment chemicals. As presented on the tables, operation and maintenance cost does not include energy (power or fuel) costs because these costs are shown separately.

Energy - The annual cost of energy is shown separately, although it is commonly included as part of operation and maintenance cost. Energy cost has been shown separately because of its importance to the nation's economy and natural resources.

Cyanide Oxidation

In this technology, cyanide is destroyed by reaction with sodium hypochlorite under alkaline conditions. A complete system for this operation includes reactors, sensors, controls, mixers, and chemical feed equipment. Control of both pH and chlorine concentration (through oxidation-reduction potential) is important for effective treatment.

Capital Costs. Capital costs for cyanide oxidation shown in Figure VIII-2 (page 360) include reaction tanks, reagent storage, mixers, sensors and controls necessary for operation. Costs are estimated for both batch and continuous systems with the operating mode selected on a least cost basis. Specific costing assumptions are as follows:

For both continuous and batch treatment, the cyanide oxidation tank is sized as an above ground cylindrical tank with a retention time of 4 hours based on the process flow. Cyanide oxidation is normally done on a batch basis; therefore, two identical tanks are employed. Cyanide is removed by the addition of sodium hypochlorite with sodium hydroxide added to maintain the proper pH level. A 60-day supply of sodium hypochlorite is stored in an in-ground covered concrete tank, 0.3 m (1 ft) thick. A 90-day supply of sodium hydroxide also is stored in an in-ground covered concrete tank, 0.3 m (1 ft) thick.

Mixer power requirements for both continuous and batch treatment are based on 2 horsepower for every 11,355 liters (3,000 gal) of tank volume. The mixer is assumed to be operational 25 percent of the time that the treatment system is operating.

A continuous control system is costed for the continuous treatment alternative. This system includes:

2	immersion pH probes and transmitters
2	immersion ORP probes and transmitters
2	pH and ORP monitors
2	2-pen recorders
2	slow process controller
2	proportional sodium hypochlorite pumps
2	proportional sodium hydroxide pumps
2	mixers
3	transfer pumps
1	maintenance kit
2	liquid level controllers and alarms, and miscellaneous electrical equipment and piping

A complete manual control system is costed for the batch treatment alternative. This system includes:

2	pH probes and monitors
1	mixer
1	liquid level controller and horn
1	proportional sodium hypochlorite pump
1	on-off sodium hydroxide pump and PVC piping from the chemical storage tanks

Operation and Maintenance Cost. Operation and maintenance costs for cyanide oxidation include labor requirements to operate and maintain the system; electric power for mixers, pumps and controls, and treatment chemicals. Labor requirements for operation and maintenance are shown in Figure VIII-3 (page xxx). As can be seen operating labor is substantially higher for batch treatment than for continuous operation. Maintenance labor requirements for continuous treatment are fixed at 150 manhours per year for flow rates below 23,000 gph and thereafter increase according to:

Labor = .00273 x (Flow-23000) + 150

Maintenance labor requirements for batch treatment are assumed to be negligible.

Annual costs for treatment chemicals and electrical power are presented in Figure VIII-4 (page 362). Chemical additions are determined from cyanide, acidity, and flow rates of the raw waste stream according to:

lbs sodium hypochlorite = 62.96 x lbs CN-
lbs sodium hydroxide = 0.8 x lbs acidity

Cyanide Precipitation

This technology reacts zinc sulfate or ferrous sulfate with the cyanide to form complex cyanide precipitates such as $Fe_4(FeCN_6)_3$ (Prussian Blue). This system, which closely follows a conventional chemical precipitation system, includes chemical feed equipment for sodium hydroxide or lime, zinc sulfate or ferrous sulfate addition, a reaction tank, agitator, control system, clarifier and pump.

Capital Costs.
The computer calculated capital costs for cyanide precipitation include costs for each of the five subsystems; 1) alkali feed system, 2) reactant feed system, 3) reaction tank with agitator; 4) clarifier, and 5) recirculation pumps and control instrumentation costs are estimated for both batch and continuous systems with the operating mode selected on a least cost basis. Specific costing assumptions are set forth below.

For both continuous and batch treatment systems, the alkali feed system is a FRP tank signed for 15 days supply with dual head metering pumps including standby. The reactant feed system includes a steel storage with dust collectors sized for 15 days supply with volumetric feeders, dual head metering pumps. The reaction tank is a lined steel tank with agitator sized for one hour retention. The clarifier, sized at 10 gal/hr sq ft. includes the support structive, sludge scraper assembly and drive unit. A continuous pump and control system is costed for the continuous alternative. This system includes:

2	immersion pH probes and transmitters
2	immersion ORP probes and transmitters
2	pH and ORP monitors
2	2-pen recorders
2	slow process controller
2	proportional sodium hypochlorite pumps
2	proportional sodium hydroxide pumps
2	mixers
3	transfer pumps
1	maintenance kit
2	liquid level controllers and alarms, and miscellaneous electrical equipment and piping
2	immersion pH probes and transmitters
2	immersion ORP probes and transmitters
2	pH and ORP monitors
2	2-pen recorders
2	slow process controller
2	proportional reactant pumps
2	proportional sodium hydroxide pumps
2	mixers
3	transfer pumps
1	maintenance kit
2	liquid level controllers and alarms, and miscellaneous electrical equipment and piping
2	recycle pumps
1	sludge pump

A manual batch system is costed for the batch treatment alternative. This system includes:

2	pH probes and monitors
1	mixer
1	liquid level controller and horn
2	pH probes and monitors
1	mixer
1	liquid level controller and horn
1	proportional reactant pump
1	on-off sodium hydroxide pump and PVC piping from the chemical storage tanks

Mixer power requirements for both continuous and batch treatment are based on 2 horsepower for every 11,400 l (3,000 gal) of tank volume. The mixer is assumed to be operational 25 percent of the time that the treatment system is operating.

Operation and Maintenance Cost. Operation and maintenance costs for cyanide precipitation include labor requirements to operate and maintain the system, electric power for mixers, pumps, clarifier and controls, and treatment chemicals. Electrical requirements are also included for the chemical storage enclosures for lighting and ventilation and in the case of caustic storage, heating. The following criteria are used in establishing O&M costs:

(1) Reactant feed system

- maintenance materials - 3 percent of manufactured equipment cost
- labor for chemical unloading
    - -- 5 hrs/50,000 lb for bulk handling
    - -- 8 hrs/16,000 lb for bag feeding to the hopper
    - -- routine inspection and adjustment of feeders is 10 min/feeder/shift
- maintenance labor
    - -- 8 hrs/yr for liquid metering pumps
    - -- 24 hrs/yr for solid feeders and solution tank
- power [function of instrumentation and control, metering pump HP and volumetric feeder (bag feeding)]

(2) Caustic feed system

- maintenance materials - 3 percent of manufactured equipment cost (excluding storage tank cost)
- labor/unloading
    - -- dry NaOH - 8 hrs/16,000 lb
    - -- liquid 50 percent NaOH - 5 hrs/50,000 lb
- labor operation (dry NaOH only) - 10 min/day/feeder
- labor operation for metering pump - 15 min/day
- annual maintenance - 8 hrs
- power [includes metering pump HP, instrumentation and control, volumetric feeder (dry NaOH)]

(3) Clarifier

- maintenance materials range from 0.8 percent to 2 percent as a function of increasing size
- labor - 150 to 500 hrs/yr (depending on size)
- power - based on horsepower requirements for sludge pumping and sludge scraper drive unit

(4) Reaction vessel with agitator

- maintenance materials 6 2 percent of equipment cost
- labor

-- 15 min/mixer/day routine O&M
-- 4 hrs/mixer/6 mos - oil changes
-- 8 hrs/yr - draining, inspection, cleaning
- power - based on horsepower requirements for agitator

(5) Recycle pump

- maintenance materials - percent of manufactured equipment cost variable with flowrate
- 50 ft TDH; motor efficiency of 90 percent and pump efficiency of 85 percent

Annual costs for treatment chemicals are determined from cyanide concentration, pH, metals concentrations, and flowrate of the raw waste stream. Cost curves are not presented for this technology because the cyanide oxidation curves are judged to be close enough for graphic estimates. Computer calculated costs are precise calculations.

Chromium Reduction

This technology chemically reduces hexavalent chromium under acid conditions to allow subsequent removal of the trivalent form by precipitation as the hydroxide. Treatment may be provided in either continuous or batch mode, and cost estimates are developed for both. Operating mode for system cost estimates is selected on a least cost basis.

Capital cost. Cost estimates include all required equipment for performing this treatment technology, including reagent dosage, reaction tanks, mixers and controls. Different reagents are provided for batch and continuous treatment resulting in different system design considerations as discussed below.

For both continuous and batch treatment, sulfuric acid is added for pH control. A 90 day supply is stored in the 25 percent aqueous form in an above-ground, covered concrete tank, 0.305 m 1 ft) thick.

For continuous chromium reduction, the single chromium reduction tank is sized in an above-ground cylindrical concrete tank with a 0.305 m (1 ft) wall thickness, a 45 minute retention time, and an excess capacity factor of 1.2. Sulfur dioxide is added to convert the influent hexavalent chromium to the trivalent form.

The control system for continuous chromium reduction consists of:

1 immersion pH probe and transmitter
1 immersion ORP probe and transmitter
1 pH and ORP monitor

2 slow process controllers
1 sulfonator and associated pressure regulator
1 sulfuric acid pump
1 transfer pump for sulfur dioxide ejector
2 maintenance kits for electrodes, and miscellaneous electrical equipment and piping

For batch chromium reduction, the dual chromium reduction tanks are sized as above-ground cylindrical steel steel tanks with a 4 hour retention time, and an excess capacity factor of 1.2. Sodium bisulfite is added to reduce the hexavalent chromium.

A completely manual system is provided for batch operation. Subsidiary equipment includes:

1 sodium bisufite mixing and feed tank
1 metal stand and agitator collector
1 sodium bisulfite mixer with disconnects
1 sulfuric acid pump
1 sulfuric acid mixer with disconnects
2 immersion pH probes
1 pH monitor, and miscellaneous piping

Capital costs for batch and continuous treatment systems are presented in Figure VIII-5 (page 363).

Operation and Maintenance. Costs for operating and maintaining chromium reduction systems include labor, chemical addition, and energy requirements. These factors are determined as follows:

- LABOR

The labor requirements are plotted in Figure VIII-6 (page 364). Maintenance of the batch system is assumed to be negligible and so it is not shown.

- CHEMICAL ADDITION

For the continuous system, sulfur dioxide is added according to the following:

$$(\text{lbs } SO_2/\text{day}) = (15.43)\ (\text{flow to unit-MGD})\ (Cr^{+6}\ \text{mg/l})$$

In the batch mode, sodium bisulfite is added in place of sulfur dioxide according to the following:

$$(\text{lbs } NaHSO3/\text{day}) = (20.06)\ (\text{flow to unit-MGD})\ (Cr^{+6}\ \text{mg/l})$$

ENERGY

Two horsepower is required for chemical mixing. The mixers are assumed to operate continuously over the operation time of the treatment system.

Given the above requirements, operation and maintenance costs are calculated based on the following:

- $6.00 per man + 10% indirect labor charge
- $380/ton of sulfur dioxide
- $20/ton of sodium bisulfite
- $0.032/kilowatt hour of required electricity

Oil Skimming

This technology removes oils from process wastewater by gravity separation and subsequent removal of the surface layer of oil. A baffled tank provides quiescent conditions conducive to separation of oil droplets and retention of floating oil behind an underflow baffle.

Capital Cost. The costing analyses for the API Oil Skimming process were based upon an optimization of the one channel oil separator design by expanding the API design standards. The following assumptions were used for costing purposes:

1. The unit was assumed to be an in-the-ground rectangular cross-section concrete tank with a maximum horizontal stream velocity set to the smaller of 3 fpm or 4.72 times the oil rise rate.

2. The depth-to-width ratio was maintained between 0.3-0.5 to minimize tank size.

3. The depth was maintained between 3 ft. minimum and 8 ft. maximum, and the width between 6 ft. minimum and 20 ft. maximum to provide minimum tank size.

4. The costs were based on a 0.3 m (1 ft) concrete thickness and include the excavation required.

Figure VIII-7 (page 365) presents estimated oil separator capital costs. Flows up to 0.25 MGD are costed for a single unit; flows greater than 0.25 MGD, require more than one unit.

Operation and Maintenance Cost. Only labor is included in the operation and maintenance costs of the skimmer since other costs were considered negligible in comparison. Figure VIII-8 (page

366) illustrates the correlation used to calculate the required man-hours for operation and maintenance. The total man-hours are then multiplied by the $6.00 per hour labor rate plus 10 percent indirect labor charge.

Chemical Precipitation and Clarification

This technology removes dissolved pollutants by first reacting added lime and sodium sulfide to form precipitates and then removing the precipitated solids by gravity settling in a clarifier. Several distinct operating modes and construction techniques are costed to provide least cost treatment over a broad range of flow rates. Because of their interrelationships and integration in common equipment in some installations, both the chemical addition and solids removal equipment are addressed in a single subroutine.

Investment Cost. Investment costs are determined for this technology for continuous treatment and for batch treatment systems using steel tank construction. The least cost system is selected for each application. Continuous treatment systems include a mix tank for reagent feed addition and a clarification basin with associated sludge rakes and pumps. Batch treatment includes only reaction-settling tanks and sludge pumps.

For the continuous treatment systems, construction is different for flows above and below 10,000 l/hr (2700 gph). For flow rates greater than or equal to 10,000 l/hr, the continuous treatment system costs include a flocculator, settling tank, and associated equipment. For flow rates less than 10,000 l/hr, the continuous clarifier costs include two above-ground tanks instead of the flocculator-settling tank combination.

The in-ground flocculator is a conrete unit. The size is based on a 45 minute retention time, a length to width ratio of 5, a depth of 8 feet, and a 40 percent excess capacity. Capital costs include excavation and a mixer. The estimated flocculator cost for batch operation is shown in Figure VIII-9 (page 367).

The settling tank is a steel unit sized for a hydraulic loading of 15.0 gph/sq ft, a 4 hour retention time, and an excess capacity of 40 percent. The two conical unlined carbon steel tanks are sized for four hour retention in each tank. Capital costs include excavation and a skimmer. Figure VIII-10 (page 368) shows the combined flocculator - settling tank cost for batch operation.

cost for these tanks for flows less than 1000 l/hr (2604 gph).

A cost of $3202 is included in capital cost estimates for sludge pumps regardless of whether the dual tanks or the flocculator-settling tank combination is used. This cost covers the expense for two centrifugal sludge pumps.

For batch treatment, dual cylindrical carbon steel tanks sized for 8 hour retention and 40 percent excess capacity are used. If the required tank volume exceeds 50,000 gallons, then costs for field fabrication are included. The capital cost for the batch system (not including the sludge pump costs) is shown in Figure VIII-11 (page 369). The capital cost estimate for batch treatment also includes a fixed $3,202 cost for sludge pumps as discussed above.

Figure VIII-12 (page 370) shows a comparison of the capital cost curves for the modes discussed above. These curves include sludge pump costs.

All costs include motors, starters, alternators, and necessary piping.

Operation and Maintenance Cost

The operation and maintenance costs for the chemical precipitation and clarification routine include:

1) Cost of chemicals added (lime, alum)
2) Labor (operation and maintenance)
3) Energy

Each of these contributing factors are discussed below.

- CHEMICAL COST

  Lime and sodium sulfide are added for metals and solids removal. The amount of chemical required is based on equivalent amounts of various pollutant parameters present in the stream entering the unit. The methods used in determining the lime requirements are shown in Table VIII-3 (page 336).

- LABOR

  Figure VIII-13 (page 371) presents the man-hour requirements for the continuous clarifier system. For the batch system, maintenance labor is assumed to be negligible and operation labor is calculated from:

(man-hours for operation) = 390 + (0.975) (lbs. lime added per day)

ENERGY

The energy costs are calculated from the treatment and sludge pump horsepower requirements.

Continuous Mode

The treatment horsepower requirement is assumed to be constant over the hours of operation of the treatment system at a level of 0.0000265 horsepower per 1 gph of flow influent to the clarifier. The sludge pumps are assumed to be operational for 5 minutes of each operational hour at a level of 0.00212 horsepower per 1 gph of sludge stream flow.

Batch Mode

The treatment horsepower requirement is assumed to occur for 7.5 minutes per operational hour at the following level:

influent flow 1042 gph; 0.0048 hp/gph

influent flow 1042 gph; 0.0096 hp/gph

The power required for the sludge pumps in the batch mode is the same as that required for the sludge pumps in the continuous mode.

Given the above requirements, operation and maintenance costs are calculated based on the following:

- $6.00 per man-hour + 15% indirect labor charge
- $41.26/ton of lime
- $0.284/pound of sodium sulfide
- $0.032/kilowatt-hour of required electricity

Sulfide Precipitation - Clarification

This technology removes dissolved pollutants by the formation of precipitates by reaction with sodium sulfide, sodium bisulfide, or ferrous sulfide and lime, and subsequent removal of the precipitate by settling. As discussed for chemical precipitation and clarification, the addition of chemicals, formation of precipitates, and removal of the precipitated solids from the wastewater stream are addressed together in cost estimation because of their interrelationships and common equipment under some circumstances.

Investment Cost. Capital cost estimation procedures for sulfide precipitation and clarification are identical to those for chemical precipitation and clarification. Continuous treatment systems using steel construction and batch treatment systems are costed to provide a least cost system for each flow range and set of raw waste characteristics. Cost factors are also the same as for chemical precipitation and clarification.

Operation and Maintenance Costs. Costs estimated for the operation and maintenance of a sulfide precipitation and clarification system are also identical to those for chemical precipitation and clarification except for the cost of treatment chemicals. Lime is added prior to sulfide precipitation to achieve an alkaline pH of approximately 8.5-9 and this precipitates some pollutants as hydroxides or calcium salts. Lime consumption based on both neutralization and formation of precipitates is calculated to provide a 10 percent excess over stochiometric requirements. Sulfide costs are based on the addition of ferrous sulfate and sodium bisulfide (NaHS) to form a 10 percent excess of ferrous sulfide over stoichiometric requirements for precipitation. Reagent additions are calculated as shown in Table VIII-4 (page 343) . Labor and energy rates are identical to those shown for chemical precipitation and clarification.

Multi-Media Filtration

This technology removes suspended solids by filtering them through a bed of particles of several distinct size ranges. As a polishing treatment after chemical precipitation and clarification multi-media filtration improves the removal of precipitates and thereby improving removal of the original dissolved pollutants.

Capital Cost. The size of the multi-media filtration unit is based on 20 percent excess flow capacity and a hydraulic loading of 0.5 ft^2/gpm. The capital cost, presented in Figure VIII-14 (page 372) as a function of flow rate, includes a backwash mechanism, pumps, controls, media and installation. Minimum costs are obtained using a minimum filter surface area of 60 ft^2.

Operation and Maintenance. The costs shown in Figure VIII-14 for operation and maintenance includes contributions of materials, electricity and labor. These curves result from correlations made with data obtained by a major manufacturer. Energy costs are estimated to be 3 percent of total O&M.

Membrane Filtration

Membrane filtration includes addition of sodium hydroxide to form metal precipitates and removal of the precipitated solids on a membrane filter. As a polishing treatment, it minimizes metal solubility and very effectively removes precipitated hydroxides and sulfides.

Capital Cost. Based on manufacturer's data, a factor of \$52.60/gph flow to the membrane filter is used to estimate capital cost. Capital cost includes installation.

Operation and Maintenance Cost. The operation and maintenance costs for membrane filtration include:

1) Labor
2) Sodium Hydroxide Added
3) Energy

Each of these contributing factors are discussed below.

- LABOR

2 man-hours per day of operation are included.

- SODIUM HYDROXIDE ADDITION

Sodium hydroxide (or lime) is added to precipitate metals as hydroxides or to insure a pH favorable to sulfide precipitation. The amount of sodium hydroxide required is based on equivalent amounts of various pollutant parameters present in the stream entering the membrane filter. The method used to determine the sodium hydroxide demand is shown below:

POLLUTANT	ANaOH
Chromium, Total	0.000508
Copper	0.000279
Acidity	0.000175
Iron, DIS	0.000474
Zinc	0.000268
Cadmium	0.000158
Cobalt	0.000301
Manganese	0.000322
Aluminum	0.000076

(Sodium Hydroxide Per Pollutant, lb/day) = ANaOH x Flow Rate (GPH) x Pollutant Concentration (mg/l)

- ENERGY

  The horsepower required is as follows:

  2 1/2-horsepower mixers operating 34 minutes per operational hour

  2 1-horsepower pumps operating 37 minutes per operational hour

  1 20-horsepower pump operating 45 minutes per operational hour

Given the above requirements, operation and maintenance costs are calculated based on the following:

- $6.00 per man-hour + 15% indirect labor charge
- $0.11 per pound of sodium hydroxide required
- $0.032 per kilowatt-hour of energy required

Ultrafiltration

Capital Cost. The capital cost for ultrafiltration is calculated using a correlation developed from data supplied by a major manufacturer. Figure VIII-15 (page 373) illustrates the results for this correlation.

Operation and Maintenance Cost

The unit is sized on the basis of a hydraulic loading of 1,430 l/day/ m^2 of surface area and an excess capacity factor of 1.2. The operation and maintenance costs are made up of contributions from:

1) Labor
2) Membrane Replacement
3) Energy

Each of these factors are discussed below.

- LABOR

  Figure VIII-16 (page 374) shows curves of the man-hour requirements for both maintenance and operation.

- MEMBRANE REPLACEMENT

  One filter module is required per year for each 500 gallons per day of treated flow.

- ENERGY

The power requirements based on 30.48 m of pumphead yield a constant horsepower value of 0.006 horsepower/flow to the ultrafiltration unit.

Given the above requirements, opeation and maintenance costs are calculated based on the following:

- $6.00 per man-hour + 15 percent indirect labor charge
- $218/ultrafiltration module
- $0.032/kilowatt-hour of required energy

Vacuum Filtration

Vacuum filtration is widely used to reduce the water content of high solids streams. In the coil coating industry, this technology is used to dewatering sludge from clarifiers, membrane filters and other waste treatment units.

Capital Cost. The vacuum filter is sized based on a typical loading of 14.6 kg of influent solids per hour per square meter of filter area (3 lbs/ft^2-hr). The curves of cost versus flow at TSS concentrations of 3 percent and 5 percent are shown in Figure VIII-17 (page 375). The capital cost obtained from this curve includes installation costs.

Operation and Maintenance Cost.

- LABOR

The vacuum filtration subroutine may be run for off-site sludge disposal or for on-site sludge incineration. On-site sludge incineration assumes a conveyor transport and reduced operating man-hours from those for off-site disposal. The required operating hours per year varies with both flow rate and the total suspended solids concentration in the influent stream. Figure VIII-18 (page 376) shows the variance of operating hours with flow and TSS concentration. Maintenance labor for either sludge disposal mode is fixed at 24 manhours per year.

- MATERIALS

The cost of materials and supplies needed for operation and maintenance includes belts, oil, grease, seals, and chemicals required to raise the total suspended solids to the vacuum filter. The amount of chemicals required (iron and alum) is based on raising the TSS concentration to the filter by 1 mg/l.

Costs of materials required as a function of flow and unaltered TSS concentrations is presented in Figure VIII-19 (page 377).

- ENERGY

Electrical costs needed to supply power for pumps and controls are presented in Figure VIII-20 (page 378). Because the required pump horsepower depends on the influent TSS level, the costs are presented as a function of flow rate and TSS level.

Contract Removal

Sludge, waste oils, and in some cases concentrated waste solutions frequently result from wastewater treatment processes. Although these may be disposed of on-site by incineration, landfill or reclamation, they are most often removed on a contract basis for off-site disposal. System cost estimates are based on contract removal of sludges and waste oils. Where only small volumes of concentrated wastewater are produced, contract-removal for off-site treatment may represent the most cost-effective approach to water pollution abatement. Estimates of solution contract-haul costs are also provided by this subroutine and may be selected in place of on-site treatment on a least-cost basis.

Capital Costs. Capital investment for contract removal is zero.

Operating Costs. Annual costs are estimated for contract removal of total waste streams or sludge and oil streams as specified in input data. Sludge and oil removal costs are further divided into wet and dry haulage depending upon whether or not upstream sludge dewatering is provided. The use of wet haulage or of sludge dewatering and dry haulage is based on least cost as determined by annualized system costs over a ten year period. Wet haulage costs are always used in batch treatment systems and when the volume of the sludge stream is less than 100 gallons per day.

Both wet sludge haulage and total waste haulage differ in cost depending on the chemical composition of the waste removed. Wastes are classified as cyanide bearing, hexavalent chromium bearing, or oily and assigned different haulage costs as shown below.

Waste Composition	Haulage Cost
-0.05 mg/l CN-	$0.45/gallon
-0.1 mg/l Cr+6	$0.20/gallon
Oil & grease-TSS	$0.12/gallon
All others	$0.16/gallon

Dry (40 percent dry solids in the sludge) sludge haul costs are estimated at $0.12 gallon.

In-process Treatment and Control Components

Three major in-process control techniques have been identified for use in reducing wastewater pollutant discharges from coil coating facilities. Since product quench water constitutes a substantial fraction of the total process wastewater discharge, use of a cooling tower to recirculate this stream significantly reduces effluent flow rates and pollutant loads. Also the reuse of quench blowdown for three stage countercurrent cascade rinsing for cleaning and conversion coating reduces flow rates and pollutant loads. Cyanides may be eliminated from process wastewater effluents by substitution of non-cyanide chromating solutions. Cost estimates are presented for cooling towers; however, EPA did not develop specific cost estimates for substitution of non-cyanide chromating solutions because these costs are highly site specific and are not amenable to estimation on a general basis.

Quench water recirculation requires installation of a cooling tower for the quench stream.

Capital Costs. The cooling towers were sized to provide a temperature reduction through the tower of approximately 5.6ºC with an effluent temperature 3.9ºC above the ambient wet bulb temperature. Capital costs presented in Figure VIII-21 (page 379) are based on data supplied by a major manufacturer. The smallest unit available is for 10 gpm flow. For flow rates less than 10 gpm, capital (as well as operating and maintenance) costs are set to zero, and a warning is printed. The three distinct curve segments correspond to three different cooling units which are required to produce the necessary range of flow capacity.

Operation and Maintenance Costs. Operation and maintenance expenses include labor and electrical power. Labor is estimated at 252 hours per year.

Figure VIII-22 (page 380) shows the electrical energy costs for operation of the pumps and fans for the cooling tower.

Countercurrent rinsing is included in the model technology form to reduce the volume of the cleaning and conversion coating waste streams to levels necessary to allow LS&F end-of-pipe technology to be applied. Countercurrent rinsing requires additional rinse tanks or spray equipment and plumbing as compared to single-stage rinses, and extension of materials handling equipment or provision of additional manpower for finse operation.

Capital Cost. Cost estimates for countercurrent rinsing are based upon installation of a three stage system on each of the individual waste streams. The installation cost is small for a new source. Cost estimates included such variables as tank costs, recycle pump and motor costs, piping, valving, and control instrumentation costs. The investment cost curve used is the equalization tank curve (Figure VIII-23, page 381). These costs include mixers, pumps and installation. The motor costs needed for countercurrent rinse are estimated equal to the mixer costs.

Operation and Maintenance Cost. The operation and maintenance costs associated with countercurrent rinsing include labor, materials and energy. Each of these costs is discussed below.

. LABOR

Labor requirements for operation and maintenance of the pump station are based upon one hour of maintenance per week of operation for each process line associated with surface preparation. A rate of $6.00 per hour plus a 15 percent indirect labor charge (to cover the cost of employee fringe benefits) is used in determining labor costs.

. MATERIALS Annual material costs for operation and maintenance of each countercurrent rinsing system are assumed to be 3 percent of the initial system capital cost.

ENERGY

Electrical energy requirements for each countercurrent rinsing system are based upon recirculation pump motor horsepower requirements. Electrical cost is calculated based upon a charge of $0.33 per kilowatt-hour and is shown in Figure VIII-24 (page 382).

Non-cyanide chromating solutions are available which serve the same function as the cyanide bearing solutions at an approximately equal cost; however, reports indicate that use of the non-cyanide solutions requires closer process control and longer residence time in the chromating bath. The costs of reagent substitution, therefore, are not directly calculable as reagent or fixed equipment costs, but are highly dependent on process conditions at individual plants. Facilities with well-controlled processes may be able to use non-cyanide solutions with little or no cost impact, while poorly controlled facilities or facilities with marginally sized equipment could incur very high costs for major process revisions. As a result of these considerations, no general cost estimates for this technology are presented, and none are included in system cost estimates.

Summary of Treatment and Control Component Costs. Example costs for each of the treatment and control components discussed above as supplied to process wastewater streams within the coil coating category are presented in Tables VIII-4 through VIII-15 (pages 343-354). Each technology is provided with three cost levels representative of typical, low and high raw waste flow rates encountered within the category.

TREATMENT SYSTEM COST ESTIMATES

This section presents estimates of the total cost of wastewater treatment and control systems which incorporate the treatment and control components discussed above. Median (typical), low and high flow rates in the subcategory addressed are presented for each system in order to provide an indication of the range of costs to be incurred in implementing each level of treatment. All available flow data from industry data collection portfolios were used in defining median, maximum and minimum raw waste flows, and flow breakdowns where streams are segregated for treatment. Raw waste characteristics were based on sampling data as discussed in Section V.

The system costs include component costs and subsidiary costs, including engineering, line segregation, admininstration, and interest expenses during construction. The cost estimates for BPT systems assume that none of the specified treatment and control measures are in place, so that the presented costs represent total costs for the systems. Costs are presented for BAT systems both as total system costs and as incremental costs required to modify an existing BPT system to achieve BAT.

System Cost Estimates (BPT)

This section presents the system cost estimates for the BPT end-of-pipe treatment sytems. Several flow rates are presented for each case to effectively model a wide spectrum of plant sizes.

Figure IX-1 (page 400) shows the model end-of-pipe treatment for all three basis material subcategories. The chemical oxidation of cyanide and the chemical reduction of chromium are shown as optional treatment processes. The use of either of these treatment components depends on the production processes employed at the plant. For the purpose of the BPT system cost estimates, cyanide precipitation was assumed to be a required treatment process only for the aluminum subcategory, because of the presence of cyanide in the chromating baths applied to aluminum. Chromium reduction was included in the system costs for all subcategories to treat hexavalent chromium wastes from the chromic acid sealer and conversion coating rinses, where appropriate.

The costing assumptions for each component of the BPT system were discussed above under Technology Costs and Assumptions. In addition to these components, contractor oil and sludge removal was included in all cost estimates.

Table VIII-16 (page 355) present costs for normal plant BPT treatment system influent flow rates. The basic cost elements used in preparing these tables are the same as those presented for the individual technologies: investment, annual capital cost, annual depreciation, annual operation and maintenance cost (less energy cost), energy cost, and total annual cost. These elements were discussed in detail earlier in this section.

Cost computations were based on selection of a least cost treatment system. This procedure calculated the costs for a batch treatment system, a continuous treatment system, and haulage of the complete waste water flow over a 10 year comparison period; the least expensive system was then selected for presentation in the system cost tables.

The various investment costs assume that the treatment system must be specially constructed and include all subsidiary costs discussed previously. Operation and maintenance costs assume continuous operation, 24 hours a day, 5 days per week, for 52 weeks per year.

System Cost Estimates (BAT Level I)

The BAT Level 1 alternative calls for reduction of the plant discharge flow by using in-plant technology - recirculation and reuse of quench waters.

Recirculation and reuse of quench water significantly reduces the volume of waste water discharged by a typical coil coating plant. Costs of installing and operating a cooling tower were calculated based on total quench water recirculation. Design and cost assumptions for the cooling tower were discussed previously.

Table VIII-17 (page 356) presents example cost data for construction and operation of BAT Level I treatment facilities for normal plants with no existing wastewater treatment. Figure X-1 (page 429) depicts the components of the end-of-pipe system. Quench water recirculation is integrated within the process line.

System Cost Estimates (BAT Level II)

System cost estimates for adding a multimedia filter to the BAT Level 1 end-of-pipe system were developed to provide BAT Level 2 treatment cost estimates A schematic of this end-of-pipe system which is similar to the proposed BAT is shown in Figure X-2 (page 430). The costing assumptions for the multimedia filter were discussed earlier.

Table VIII-18 (page 357) present example BAT Level II treatment costs for construction of the entire end-of-pipe system. These costs represent anticipated expenditures to attain BAT Level II for a plant with no treatment in place.

System Cost Estimates - (New Sources)

The suggested treatment system for NSPS is displayed in Figure XI-3 (page 445), and costs are presented in Table VIII-19 (page 358). Thesystem costs include quench water recirculation costs as discussed previously for BAT Level 1.

System Cost Estimates - (Pretreatment)

The model treatment technology for pretreatment at existing sources (PSES) is the same as the BAT 1 treatment system and the model treatment system for new sources (PSNS) is the same as the NSPS treatment system. Estimates of construction and operation of PSES and PSNS treatment facilities for normal plants with no existing wastewater treatment are the same as BAT 1 and NSPS, respectifely (See Tables VIII-17 and VIII-19).

Use of Cost Estimation Results

Cost estimates presented in the tables in this section are for treatment and control equivalent to the specified level. They will not, in general, correspond precisely to cost experience at any individual plant. Specific plant conditions such as age, location, plant layout, or present production and treatment practices may yield costs which are either higher or lower than the presented costs. Because the costs shown are total system costs and do not assume any treatment in place, it is probable that most plants will require smaller expenditures to reach the specified levels of control from their present status.

The actual costs of installing and operating a BPT system at a particular plant may be substantially lower than the tabulated values. Reductions in investment and operating costs are possible in several areas. Design and installation costs may be reduced by using plant workers. Equipment costs may be reduced by using or modifying existing equipment instead of purchasing all new equipment. Application of an excess capacity factor, which increases the size of most equipment foundation costs could be reduced if an existing concrete pad or floor can be utilized. Equipment size requirements may be reduced by the ease of treatment (for example, shorter retention time) of particular waste streams. Substantial reduction in both investment and operating cost may be achieved if a plant reduces its water use rate below that assumed in costing.

ENERGY AND NON-WATER QUALITY ASPECTS

Energy Aspects

Energy aspects of the wastewater treatment processes are important because of the impact of energy use on our natural resources and on the economy. Electrical power and fuel requirements (coal, oil, or gas) are listed in units of kilowatt hours per ton of dry solids for sludge and solids handling. Specific energy uses are noted in the "Remarks" column.

Energy requirements are generally low, although evaporation can be an exception if no waste heat is available at the plant. If evaporation is used to avoid discharge of pollutants, the influent water rate should be minimized. For example, an upstream reverse osmosis or ultrafiltration unit can drastically reduce the flow of wastewater to an evaporation device.

Non-Water Quality Aspects

It is important to consider the impact of each treatment process on air, noise, and radiation pollution of the environment to preclude the development of a more adverse environmental impact.

In general, none of the liquid handling processes causes air pollution. With sulfide precipitation, however, the potential exists for evolution of hydrogen sulfide, a toxic gas. Proper control of pH in treatment eliminates this problem. Alkaline chlorination for cyanide destruction and chromium reduction using sulfur dioxide also have potential atmospheric emissions. With proper design and operation, however, air pollution impacts are eliminated. Incineration of sludges or solids can cause significant air pollution which must be controlled by suitable bag houses, scrubbers or stack gas precipitators as well as proper incinerator operation and maintenance. None of the wastewater treatment processes causes objectionable noise and none of the treatment processes has any potential for radioactive radiation hazards.

The processes for treating the wastewaters from this category produce considerable volumes of sludges. In order to ensure long-term protection of the environment from harmful sludge constituents, special consideration of disposal sites should be made by RCRA and municipal authorities where applicable.

TABLE VIII-1

COST PROGRAM POLLUTANT PARAMETERS

Parameter, Units

Flow, MGD
pH, pH units
Turbidity, Jackson Units
Temperature, degree C
Dissolved Oxygen, mg/l
Residual Chlorine, mg/l
Acidity, mg/l $CaCO_3$
Alkalinity, mg/l $CaCO_3$
Ammonia, mg/l
Biochemical Oxygen Demand, mg/l
Color, Chloroplatinate units
Sulfide, mg/l
Cyanides, mg/l
Kjeldahl Nitrogen, mg/l
Phenols, mg/l
Conductance, micromhos/cm
Total Solids, mg/l
Total Suspended Solids, mg/l
Setteable Solids, mg/l
Aluminum, mg/l
Barium, mg/l
Cadmium, mg/l
Calcium, mg/l
Chromium, Total, mg/l
Copper, mg/l
Fluoride, mg/l
Iron, Total, mg/l
Lead, mg/l
Magnesium, mg/l
Molybdenum, mg/l
Total Volatile Solids, mg/l

Parameter, Units

Oil, Grease, mg/l
Hardness, mg/l $CaCO_3$
Chemical Oxygen Demand, mg/l
Algicides, mg/l
Total Phosphates, mg/l
Polychlorobiphenyls, mg/l
Potassium, mg/l
Silica, mg/l
Sodium, mg/l
Sulfate, mg/l
Sulfite, mg/l
Titanium, mg/l
Zinc, mg/l
Arsenic, mg/l
Boron, mg/l
Iron, Dissolved, mg/l
Mercury, mg/l
Nickel, mg/l
Nitrate, mg/l
Selenium, mg/l
Silver, mg/l
Strontium, mg/l
Surfactants, mg/l
Beryllium, mg/l
Plasticizers, mg/l
Antimony, mg/l
Bromide, mg/l
Cobalt, mg/l
Thallium, mg/l
Tin, mg/l
Chromium, Hexavalent, mg/l

TABLE VIII-2

WASTEWATER SAMPLING FREQUENCY

Wastewater Discharge (liters per day)	Sampling Frequency
0 - 37,850	once per month
37,850 - 189,250	twice per month
189,250 - 378,500	once per week
378,500 - 946,250	twice per week
946,250+	thrice per week

TABLE VIII-3

CLARIFIER CHEMICAL REQUIREMENTS

LIME REQUIREMENT*

POLLUTANT	A_{LIME}
Chromium, Total	0.000470
Copper	0.000256
Acidity	0.000162
Iron, Dissolved	0.000438
Zinc	0.000250
Cadmium	0.000146
Cobalt	0.000276
Manganese	0.000296
Aluminum	0.000907

* (Lime Demand Per Pollutant, lbs/day) = A_{Lime} x Flow Rate (GPH) x Pollutant Concentration (mg/l)

TABLE VIII-4

CONTINUOUS CYANIDE OXIDATION TREATMENT COSTS

System Flow Rate - liters/hr (gals/day)	3154. (20000.)	1577. (10000.)	252. (1600.)
Investment	55436.246	49425.184	41934.156
Annual Costs			
Capital Costs	3478.402	3101.223	2631.195
Depreciation	5543.621	4942.516	4193.414
Operating and Maintenance Costs (Excluding Energy and Power Costs)	1586.535	1383.234	1125.162
Energy and Power Costs	179.391	89.696	14.351
TOTAL ANNUAL COSTS	10787.945	9516.664	7964.117

TABLE VIII-5

BATCH CYANIDE OXIDATION TREATMENT COSTS

System Flow Rate - liters/hr (gals/day)	3154. (20000.)	1577. (10000.)	252. (1600.)
Investment	26350.004	20338.941	12847.922
Annual Costs			
Capital Costs	1653.351	1276.186	806.154
Depreciation	2635.000	2033.990	1284.792
Operating and Maintenance Costs (Excluding Energy and Power Costs)	7879.973	3939.990	630.398
Energy and Power Costs	179.391	89.696	14.351
TOTAL ANNUAL COSTS	12347.715	7339.762	2735.694

TABLE VIII-6

CONTINUOUS CHROMIUM REDUCTION TREATMENT COSTS

System Flow Rate - liters/hr (gals/day)	3154. (20000.)	1577. (10000.)	252. (1600.)
Investment	22651.824	21899.258	20875.820
Annual Costs			
Capital Costs	1421.310	1374.090	1309.871
Depreciation	2265.182	2189.926	2087.582
Operating and Maintenance Costs (Excluding Energy and Power Costs)	2239.690	1513.156	844.668
Energy and Power Costs	322.905	322.905	322.905
TOTAL ANNUAL COSTS	6249.082	5400.070	4565.023

TABLE VIII-7

BATCH CHROMIUM REDUCTION
TREATMENT COSTS

System Flow Rate - liters/hr (gals/day)	3154. (20000.)	1577. (10000.)	252. (1600.)
Investment	19382.414	15243.586	9959.789
Annual Costs			
Capital Costs	1216.167	956.473	624.936
Depreciation	1938.241	1524.358	995.979
Operating and Maintenance Costs (Excluding Energy and Power Costs)	2654.711	1327.357	995.979
Energy and Power Costs	322.905	322.905	322.905
TOTAL ANNUAL COSTS	6132.020	4131.090	2156.197

TABLE VIII-8

OIL SKIMMING
TREATMENT COSTS

System Flow Rate - liters/hr (gals/day)	15771. (100000.)	4416. (28000.)	473. (3000.)
Investment	6311.102	4265.543	3604.671
Annual Costs			
Capital Costs	395.996	267.646	226.178
Depreciation	631.110	426.554	360.467
Operating and Maintenance Costs (Excluding Energy and Power Costs)	785.906	439.380	179.619
Energy and Power Costs	0.0	0.0	0.0
TOTAL ANNUAL COSTS	1813.012	1133.580	766.264

TABLE VIII-9

CONTINUOUS CHEMICAL PRECIPITATION TREATMENT COSTS

System Flow Rate - liters/hr (gals/day)	29176. (185000.)	11670. (74000.)	3154. (20000.)
Investment	74613.500	65033.004	41844.191
Annual Costs			
Capital Costs	4681.680	4080.555	2625.551
Depreciation	7461.348	6503.297	4184.418
Operating and Maintenance Costs (Excluding Energy and Power Costs)	5400.215	3783.685	2997.265
Energy and Power Costs	34.966	13.986	3.780
TOTAL ANNUAL COSTS	17578.207	14381.520	9811.008

TABLE VIII-10

BATCH CHEMICAL PRECIPITATION TREATMENT COSTS

System Flow Rate - liters/hr (gals/day)	29176. (185000.)	11670. (74000.)	3154. (20000.)
Investment	64009.352	38949.047	31069.320
Annual Costs			
Capital Costs	4016.320	2443.892	1949.470
Depreciation	6400.934	3894.905	3106.932
Operating and Maintenance Costs (Excluding Energy and Power Costs)	7973.828	4733.922	3157.762
Energy and Power Costs	1495.387	598.155	80.937
TOTAL ANNUAL COSTS	19886.469	11670.871	8295.098

TABLE VIII-11

MULTIMEDIA FILTRATION
TREATMENT COSTS

System Flow Rate - liters/hr	29176.	11670.	3154.
(gals/day)	(185000.)	(74000.)	(20000.)
Investment	46439.742	40997.281	40997.281
Annual Costs			
Capital Costs	2913.906	2572.414	2572.414
Depreciation	4643.973	4099.727	4099.727
Operating and Maintenance Costs (Excluding Energy and Power Costs)	7093.230	6064.945	6064.949
Energy and Power Costs	332.302	284.130	284.130
TOTAL ANNUAL COSTS	14983.410	13021.215	13021.219

TABLE VIII-12

MEMBRANE FILTRATION
TREATMENT COSTS

System Flow Rate - liters/hr (gals/day)	29176. (185000.)	11670. (74000.)	3154. (20000.)
Investment	404894.000	161957.500	43772.336
Annual Costs			
Capital Costs	25405.414	10162.184	2746.539
Depreciation	40489.398	16195.750	4377.230
Operating and Maintenance Costs (Excluding Energy and Power Costs)	4111.840	3703.931	3505.489
Energy and Power Costs	2714.417	2714.417	2714.417
TOTAL ANNUAL COSTS	72721.000	32776.277	13343.672

TABLE VIII-13

ULTRAFILTRATION TREATMENT COSTS

System Flow Rate - liters/hr (gals/day)	29176. (185000.)	11670. (74000.)	3154. (20000.)
Investment	554999.000	221999.562	82285.500
Annual Costs			
Capital Costs	34823.914	13929.590	5163.074
Depreciation	55499.898	22199.953	8228.547
Operating and Maintenance Costs (Excluding Energy and Power Costs)	114374.562	57493.914	25418.340
Energy and Power Costs	7542.590	3017.035	815.415
TOTAL ANNUAL COSTS	212240.937	96640.437	39625.375

TABLE VIII-14

VACUUM FILTRATION TREATMENT COSTS

System Flow Rate - liters/hr (gals/day)	252. (1600.)	104. (660.)	28. (177.)
Investment	25218.168	25218.168	25218.168
Annual Costs			
Capital Costs	1582.332	1582.336	1582.328
Depreciation	2521.817	2521.817	2521.817
Operating and Maintenance Costs (Excluding Energy and Power Costs)	7067.633	5677.867	4391.320
Energy and Power Costs	1242.477	1242.477	1242.477
TOTAL ANNUAL COSTS	12414.258	11024.496	9737.941

TABLE VIII-15

COOLING TOWER COSTS

System Flow Rate - liters/hr (gals/day)	3154 (20000)	9463 (60000)	19871 (129000)
Investment	3116	4484	6114
Annual Costs			
Capital Costs	196	281	383
Depreciation	312	448	611
Operating and Maintenance Costs (Excluding Energy and Power Costs)	1663	1663	1663
Energy and Power Costs	268	493	869
TOTAL ANNUAL COSTS	2439	2886	3528

TABLE VIII-16

BPT COSTS
NORMAL PLANT

	Steel	Galvanized	Aluminum
System Flow Rate - liters/hr	5377	4811	15670
Least Cost Operation Mode	Batch	Batch	Continuous
Investment	372887	369384	500723
Annual Costs			
Capital Costs	23397	23177	31418
Depreciation	37289	36938	50072
Operation and Maintenance Costs (Excluding Energy and Power Costs)	35623	32876	73962
Energy and Power Costs	1960	1924	2667
TOTAL ANNUAL COSTS	98269	94916	158121

TABLE VIII-17

BAT 1 COSTS
(PROMULGATED OPTION)
NORMAL PLANT

	Steel	Galvanized	Aluminum
System Flow Rate -			
liters/hr	2292	1651	4599
Least Cost Operation Mode	Batch	Batch	Batch
Investment	305033	288061	355703
Annual Costs			
Capital Costs	19139	18075	22319
Depreciation	30503	28806	35570
Operation and Maintenance Costs (Excluding Energy and Power Costs)	26043	23776	43506
Energy and Power Costs	1663	1636	1761
TOTAL ANNUAL COSTS	77350	72292	103157

TABLE VIII-18

BAT 2 COSTS
NORMAL PLANT

	Steel	Galvanized	Aluminum
System Flow Rate -			
liters/hr	2292	1651	4599
Least Cost Operation Mode	Batch	Batch	Continuous
Investment	311017	293034	364941
Annual Costs			
Capital Costs	20017	18805	23627
Depreciation	31101	29303	36461
Operation and Maintenance Costs (Excluding Energy and Power Costs)	26043	23776	43506
Energy and Power Costs	1663	1636	1761
TOTAL ANNUAL COSTS	78824	73520	105355

TABLE VIII-19

NSPS COSTS
NORMAL PLANT

	Steel	Galvanized	Aluminum
System Flow Rate -			
Liters/hr	617	632	2213
Least Cost Operation Mode	Batch	Batch	Batch
Investment	171516	172525	316802
Annual Costs			
Capital Costs	11672	11738	20507
Depreciation	17152	17253	31680
Operation and Maintenance Costs (Excluding Energy and Power Costs)	22416	22726	35764
Energy and Power Costs	47	48	1660
TOTAL ANNUAL COSTS	51287	51765	89611

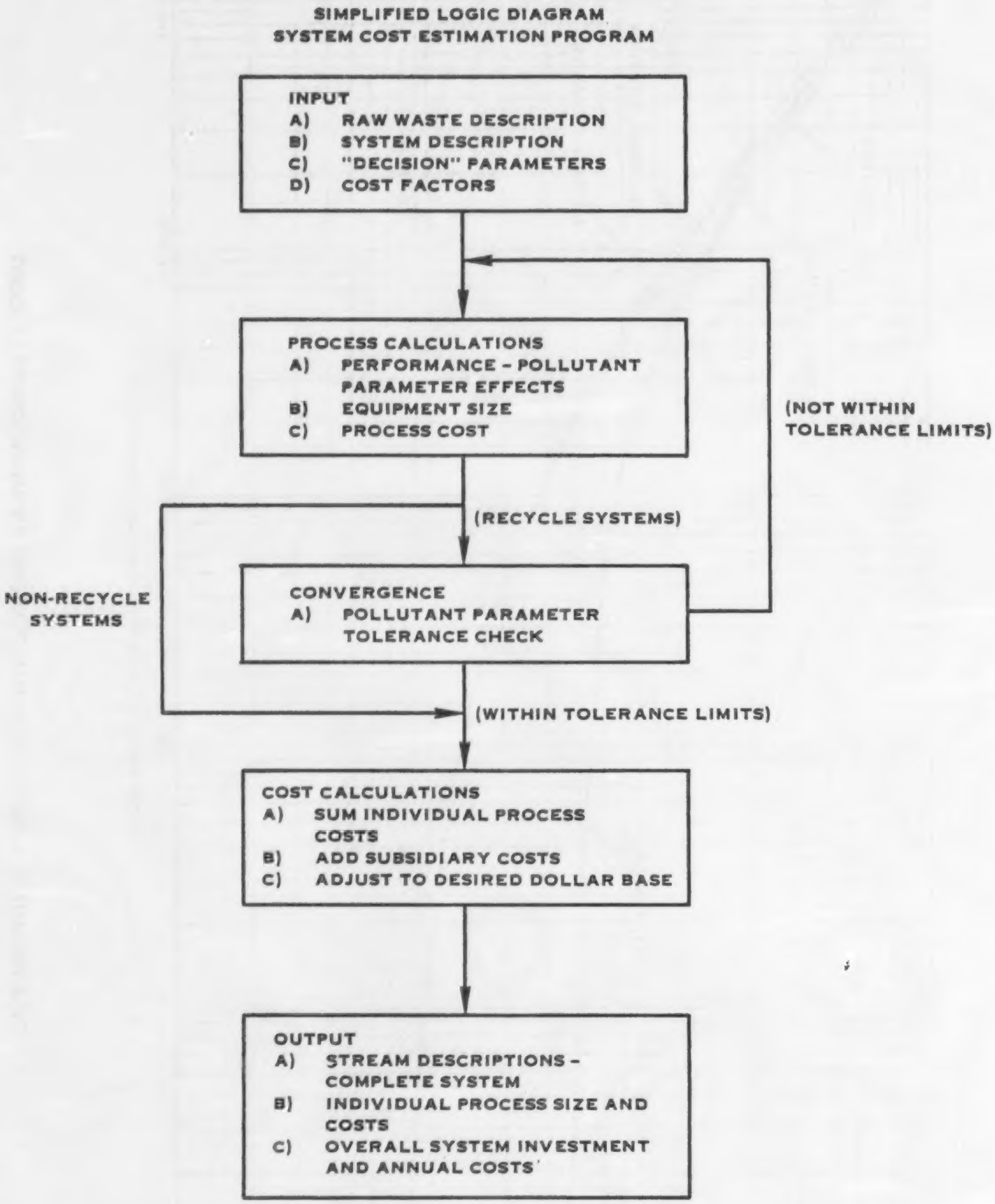

SIMPLIFIED LOGIC DIAGRAM
SYSTEM COST ESTIMATION PROGRAM
INPUT
A) RAW WASTE DESCRIPTION
B) SYSTEM DESCRIPTION
C) "DECISION" PARAMETERS
D) COST FACTORS
PROCESS CALCULATIONS
A) PERFORMANCE – POLLUTANT PARAMETER EFFECTS
B) EQUIPMENT SIZE
C) PROCESS COST
(NOT WITHIN TOLERANCE LIMITS)
(RECYCLE SYSTEMS)
NON-RECYCLE SYSTEMS
CONVERGENCE
A) POLLUTANT PARAMETER TOLERANCE CHECK
(WITHIN TOLERANCE LIMITS)
COST CALCULATIONS
A) SUM INDIVIDUAL PROCESS COSTS
B) ADD SUBSIDIARY COSTS
C) ADJUST TO DESIRED DOLLAR BASE
OUTPUT
A) STREAM DESCRIPTIONS – COMPLETE SYSTEM
B) INDIVIDUAL PROCESS SIZE AND COSTS
C) OVERALL SYSTEM INVESTMENT AND ANNUAL COSTS

FIGURE VIII-1. COST ESTIMATION PROGRAM

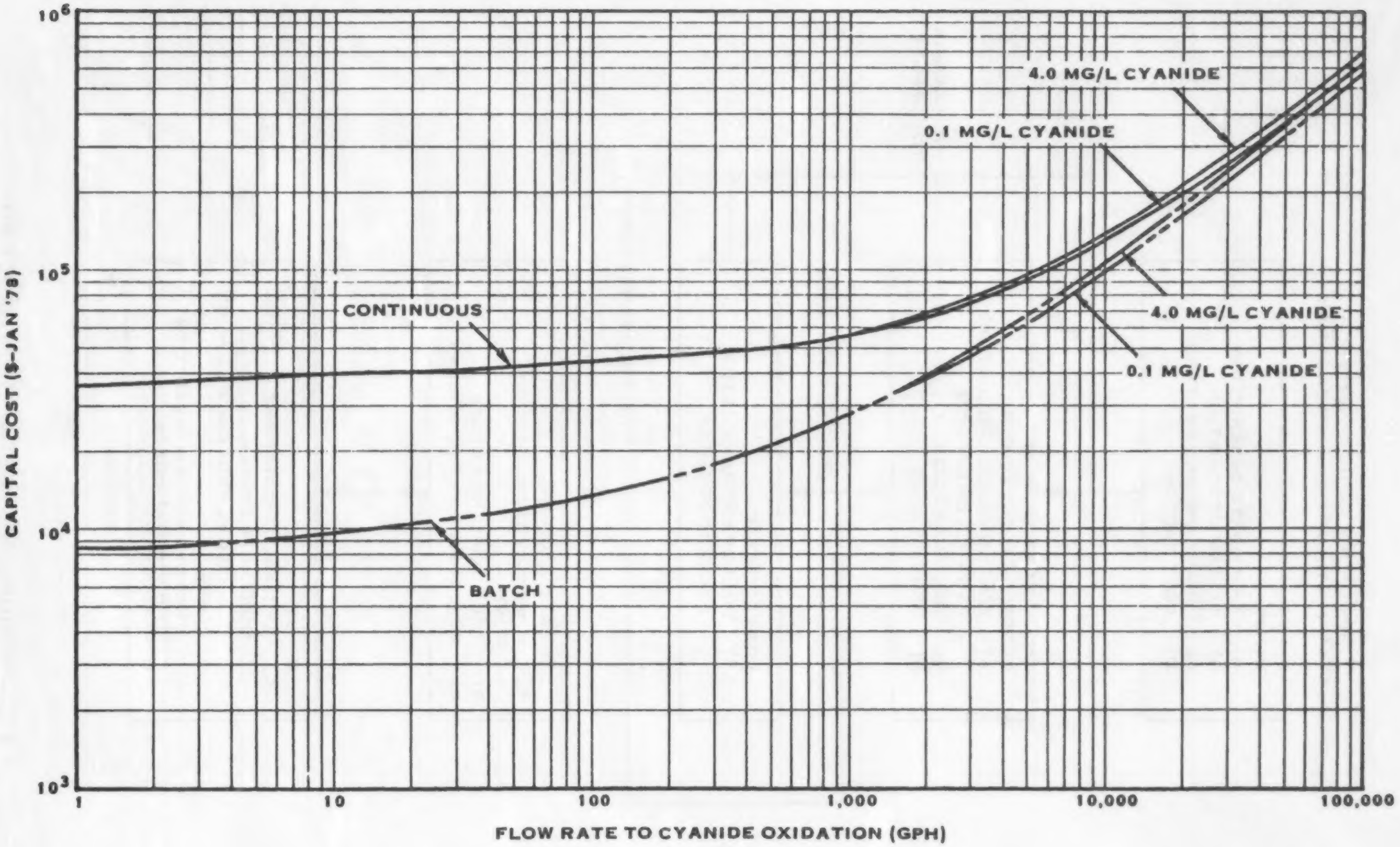


FIGURE VIII-2. CHEMICAL OXIDATION OF CYANIDE CAPITAL COST

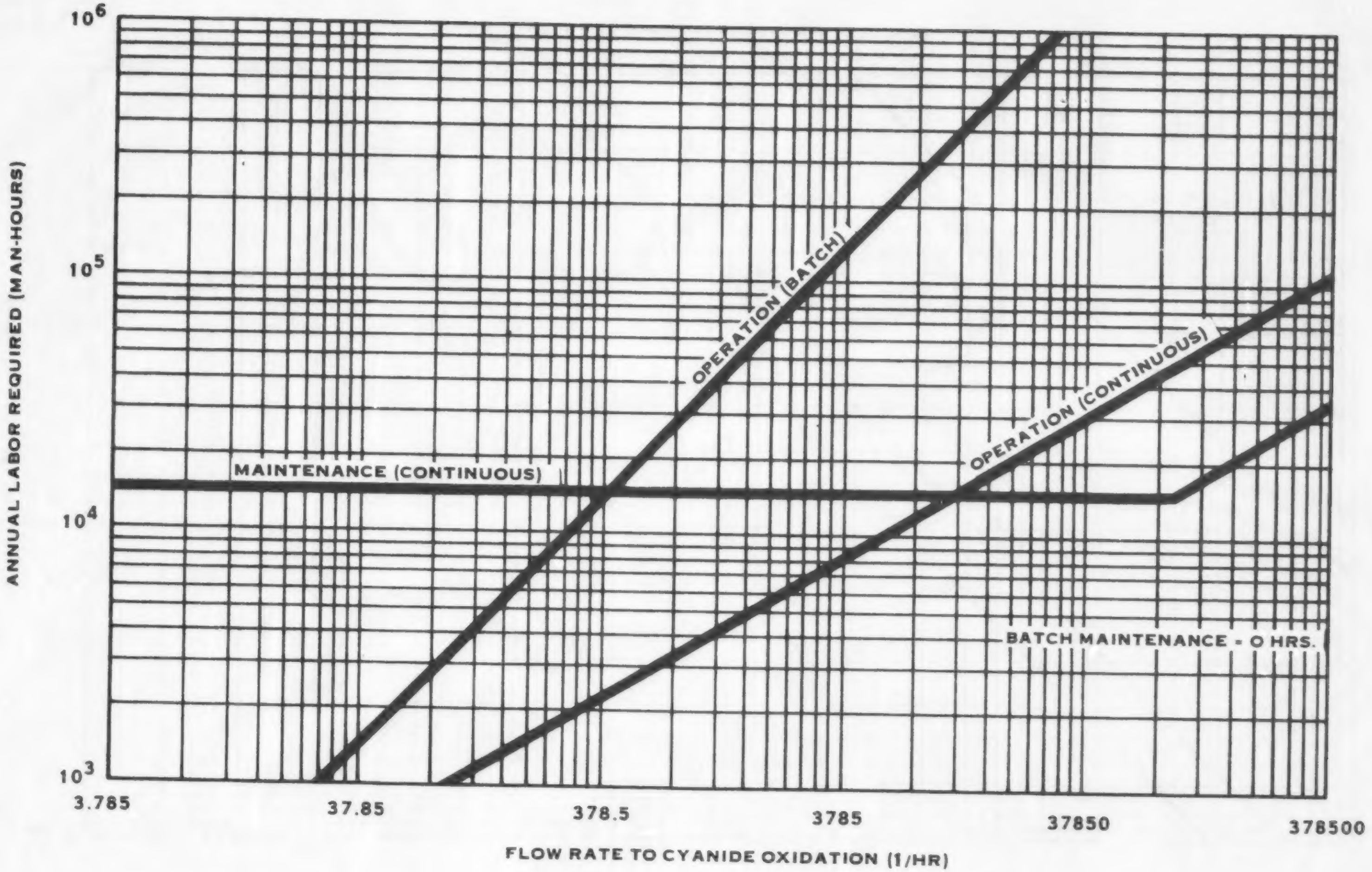


FIGURE VIII-3. CHEMICAL OXIDATION OF CYANIDE ANNUAL LABOR REQUIREMENTS

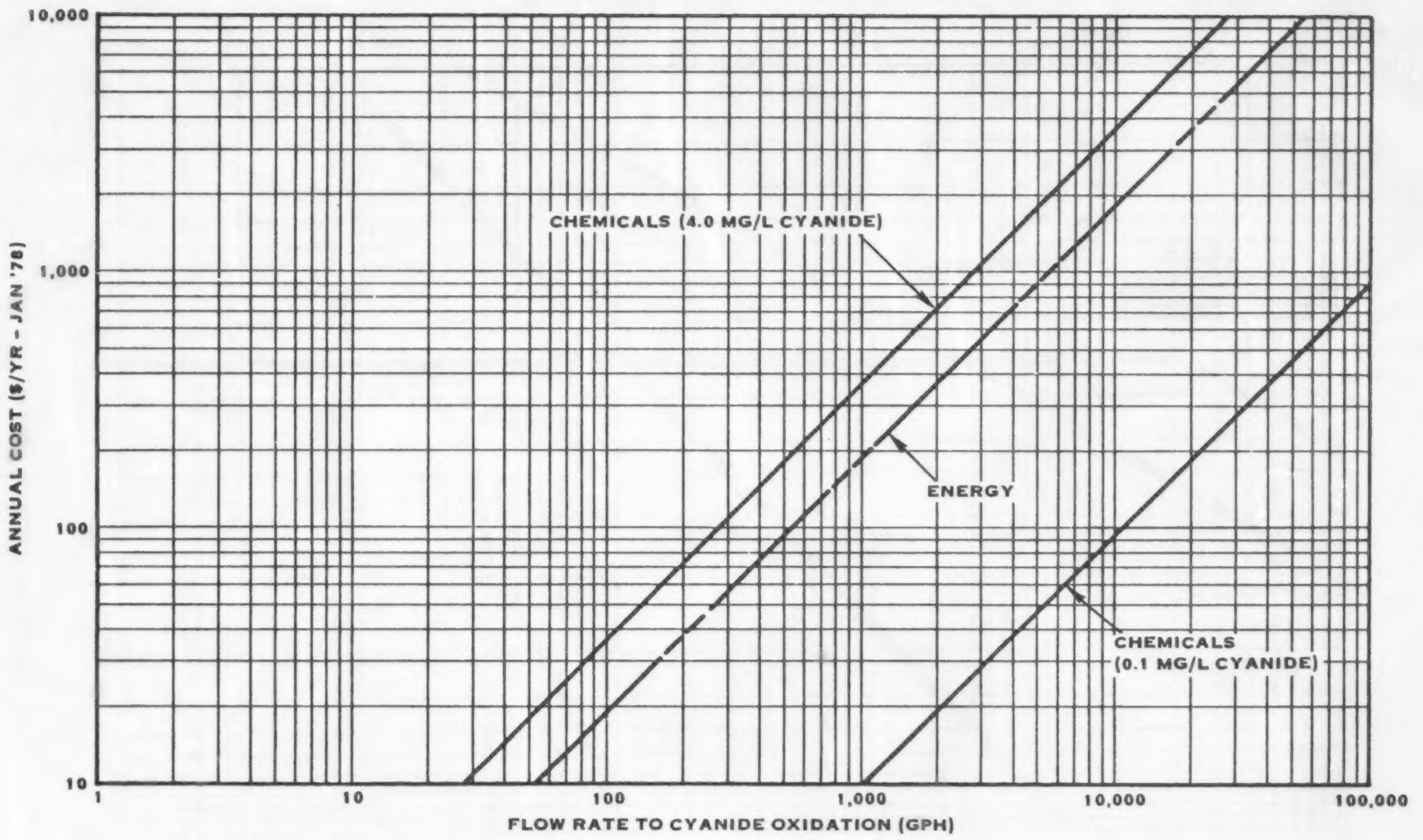


FIGURE VIII-4. CHEMICAL OXIDATION OF CYANIDE CHEMICAL AND ENERGY COST

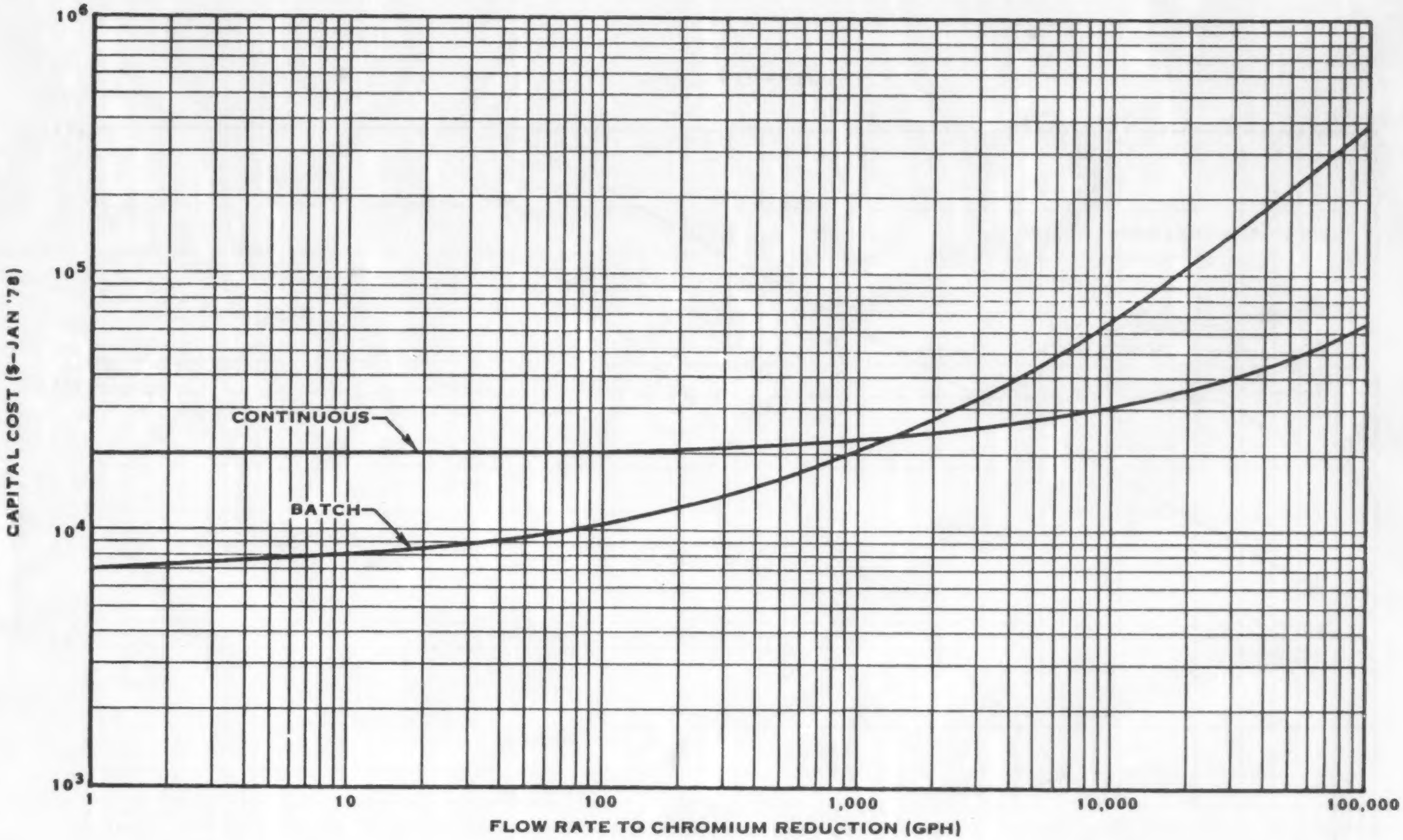


FIGURE VIII-5. CHEMICAL REDUCTION OF CHROMIUM CAPITAL COST

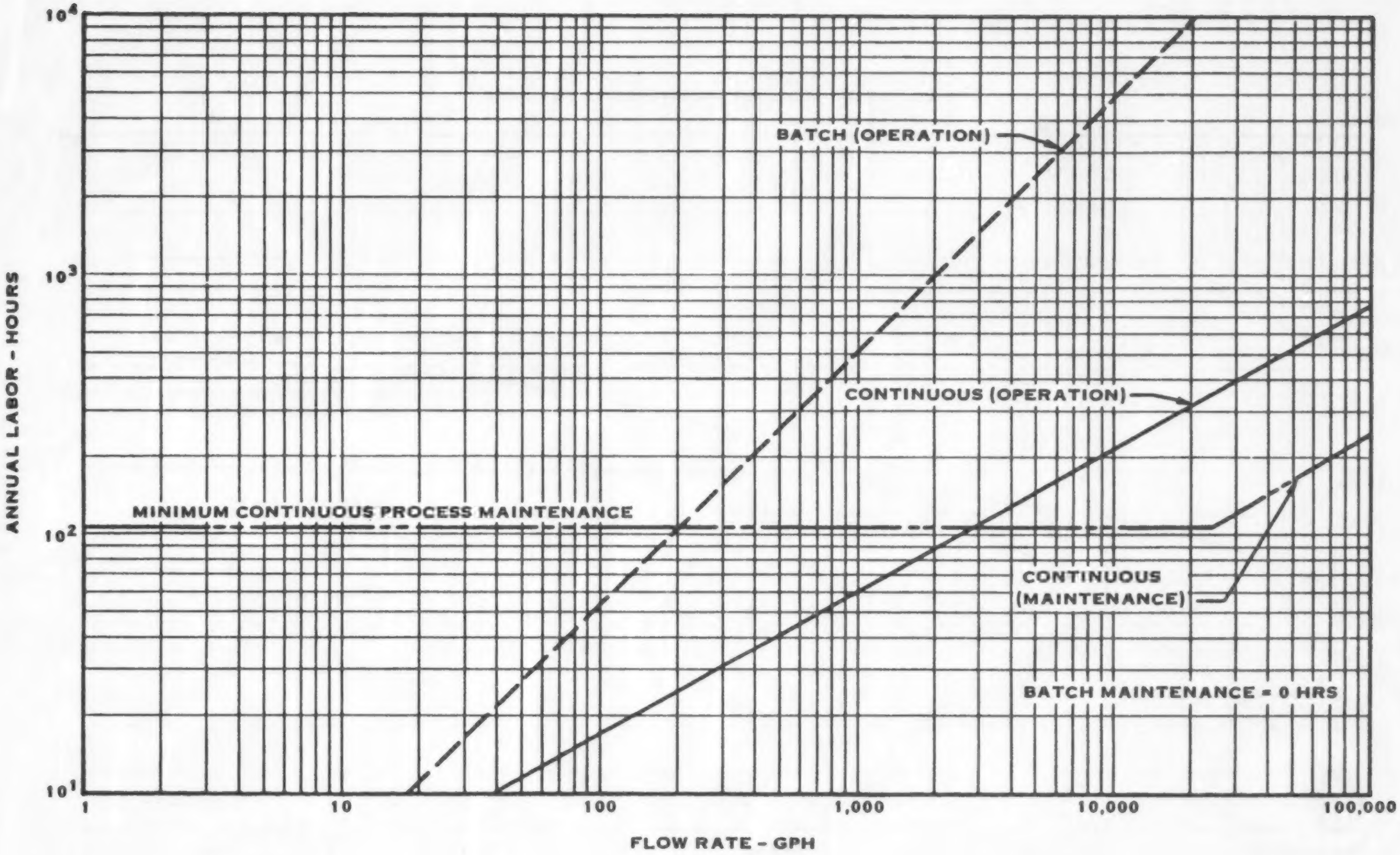


FIGURE VIII-6. CHEMICAL REDUCTION OF CHROMIUM ANNUAL LABOR REQUIREMENTS

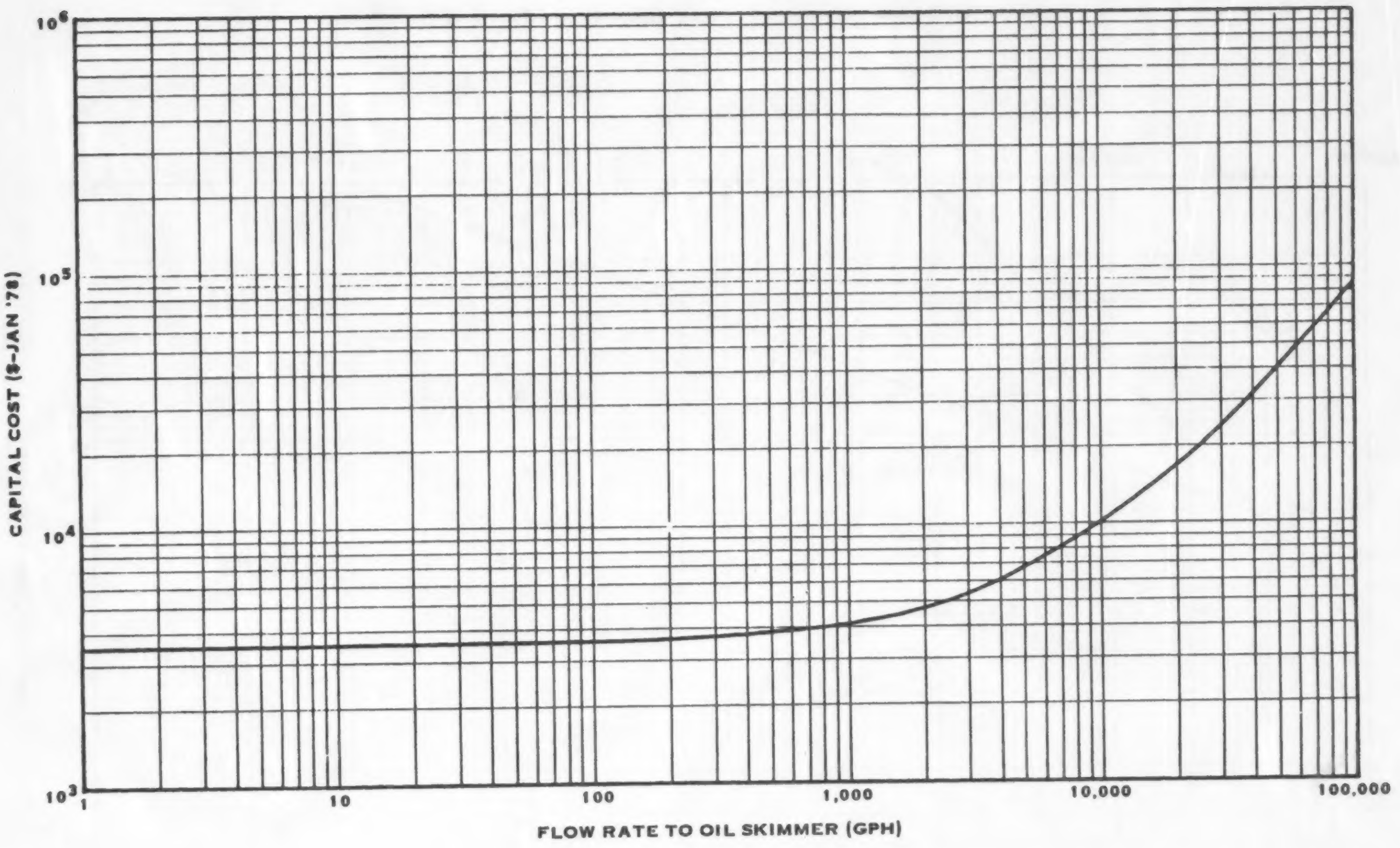


FIGURE VIII-7. OIL SKIMMER CAPITAL COST

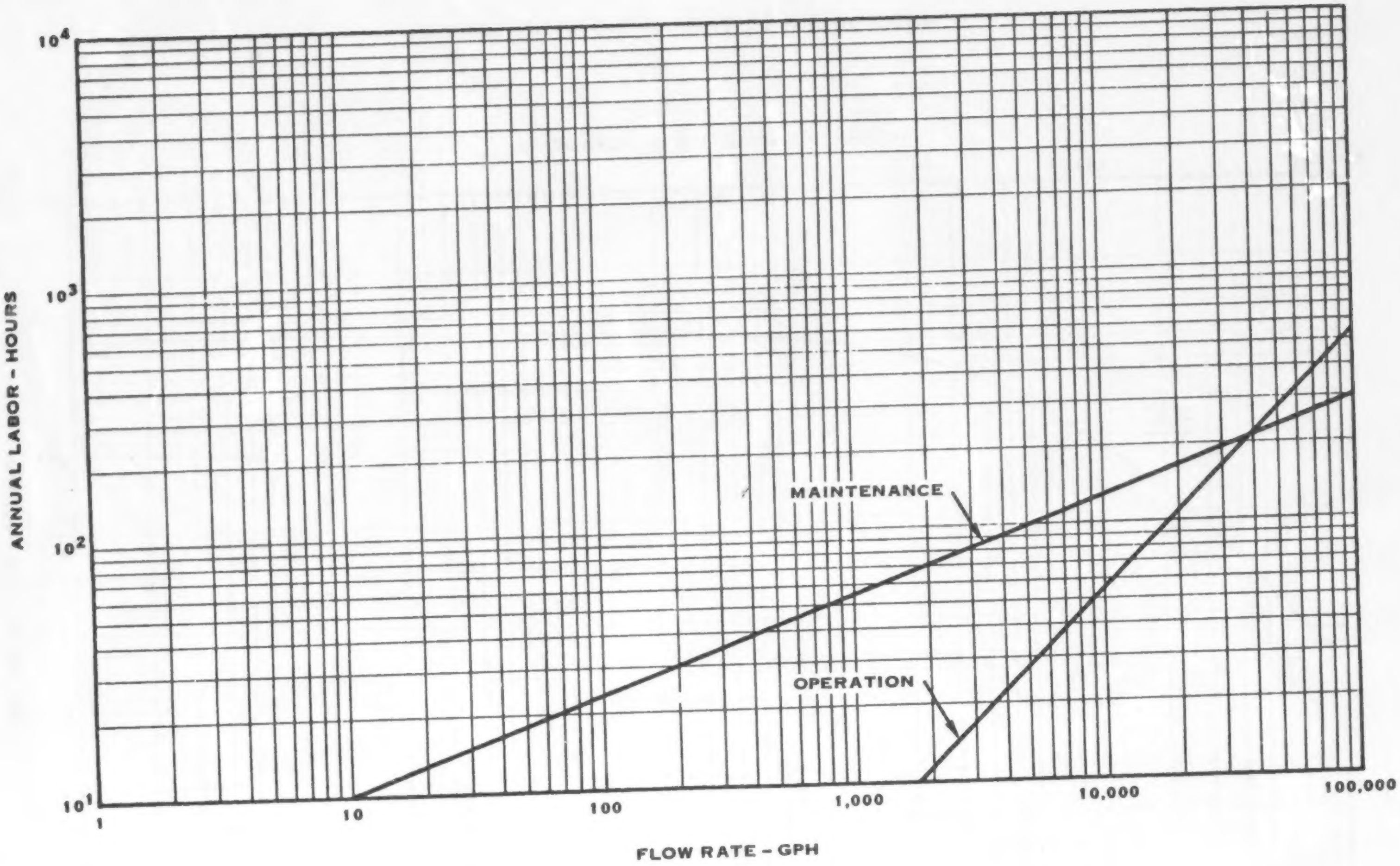


FIGURE VIII-8. OIL SKIMMER ANNUAL LABOR REQUIREMENTS

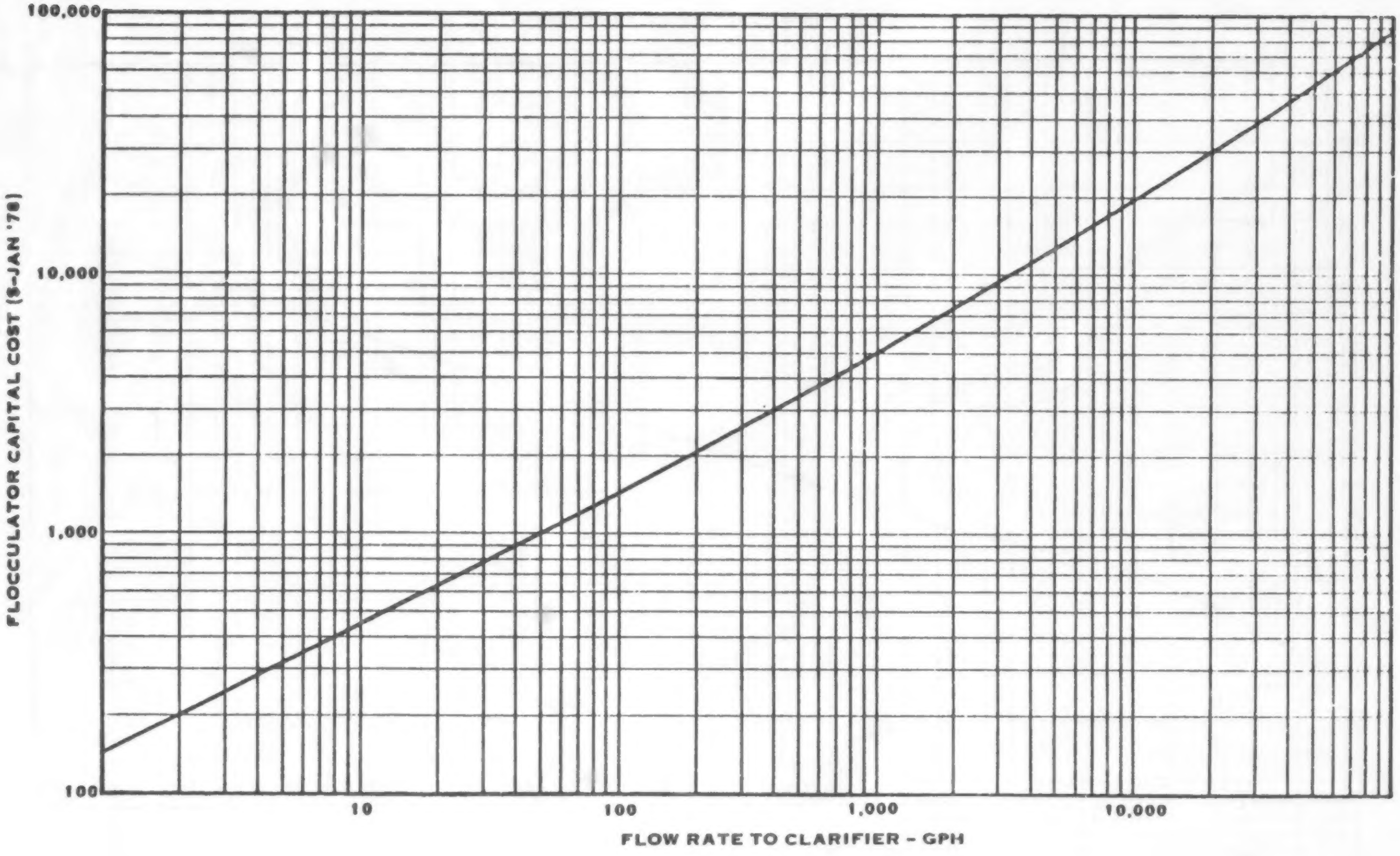


FIGURE VIII-9. FLOCCULATOR CAPITAL COST

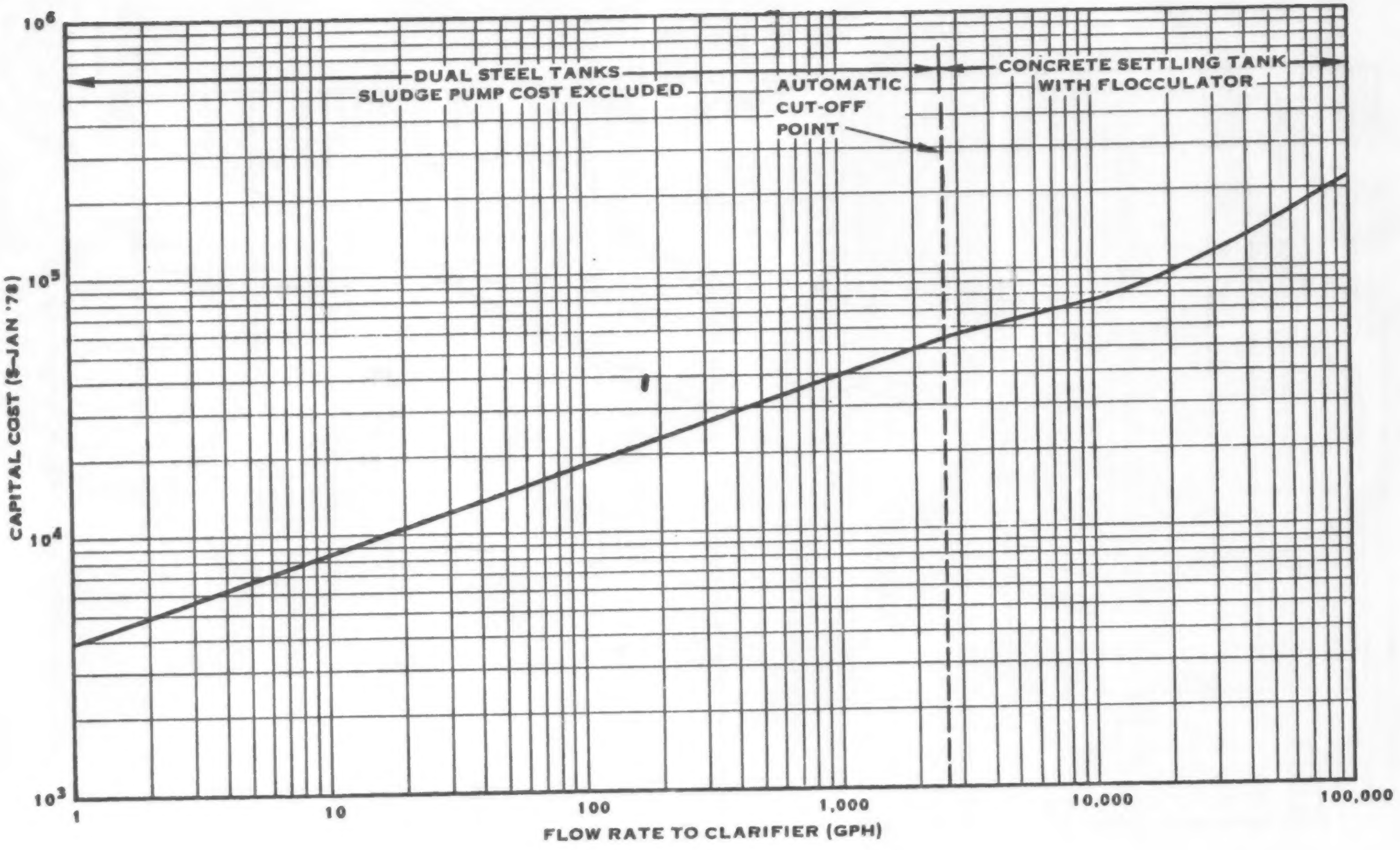


FIGURE VIII-10. CLARIFICATION CAPITAL COST FOR CONTINUOUS OPERATION

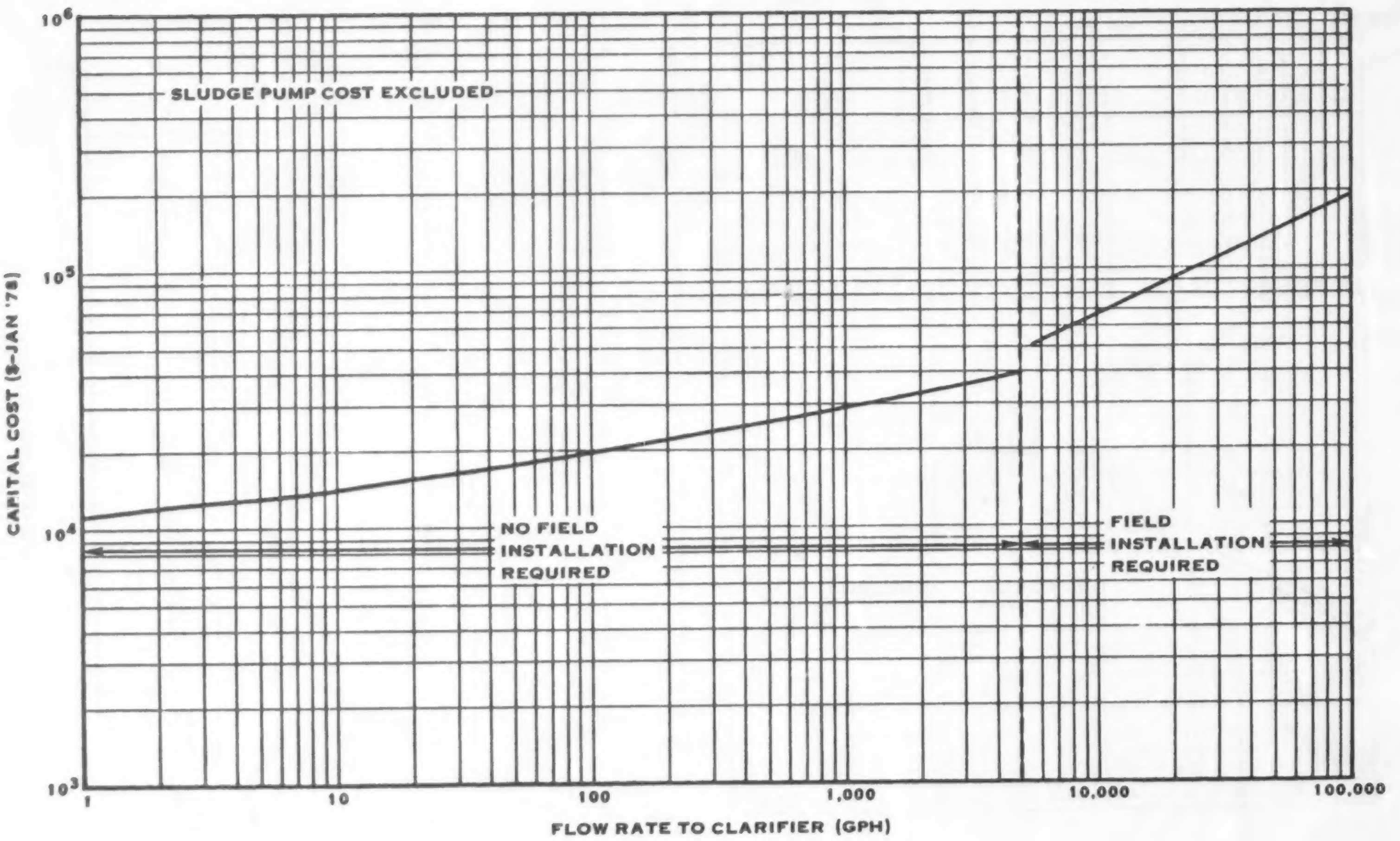


FIGURE VIII-11. CLARIFICATION CAPITAL COST FOR BATCH OPERATION

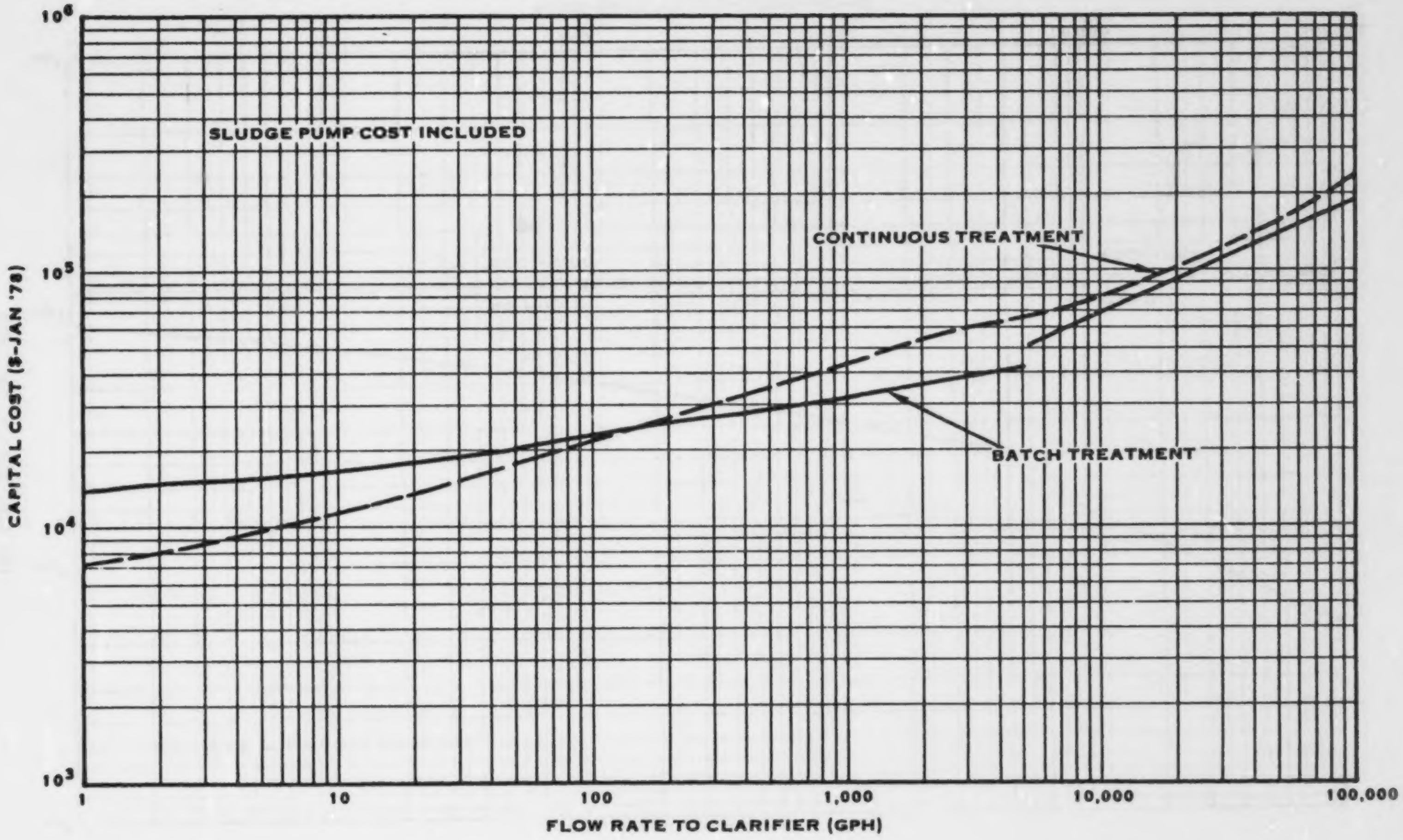


FIGURE VIII-12. CLARIFICATION COST SUMMARY

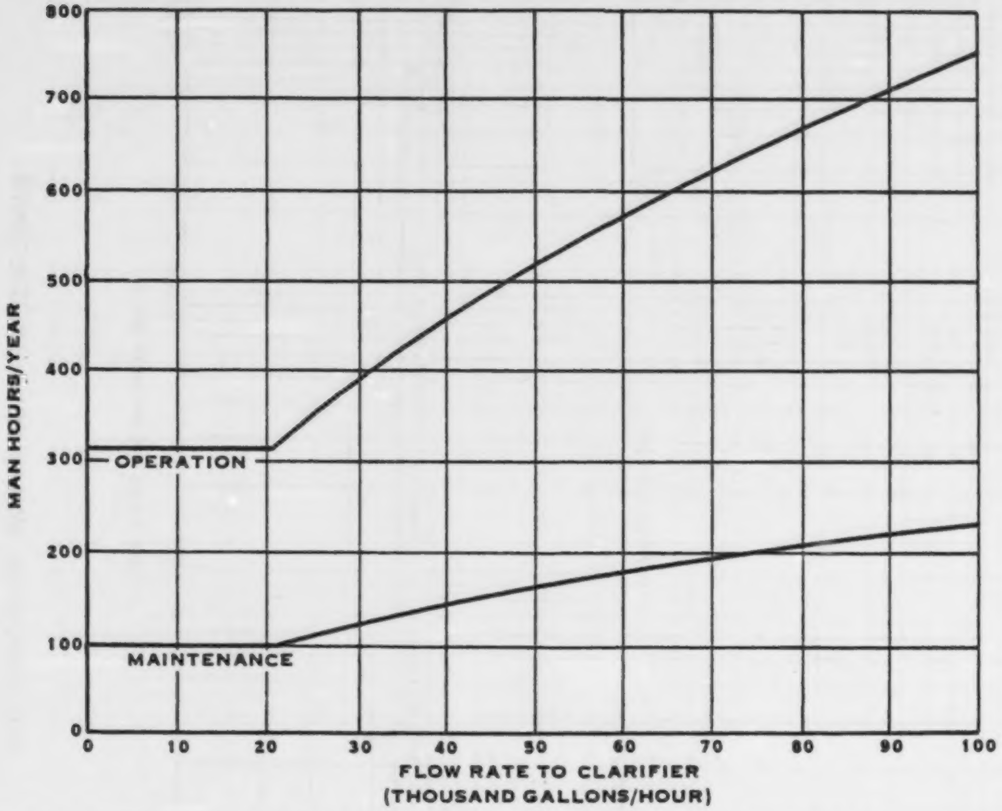


FIGURE VIII-13. CLARIFICATION MAN HOUR REQUIREMENTS FOR CONTINUOUS OPERATION

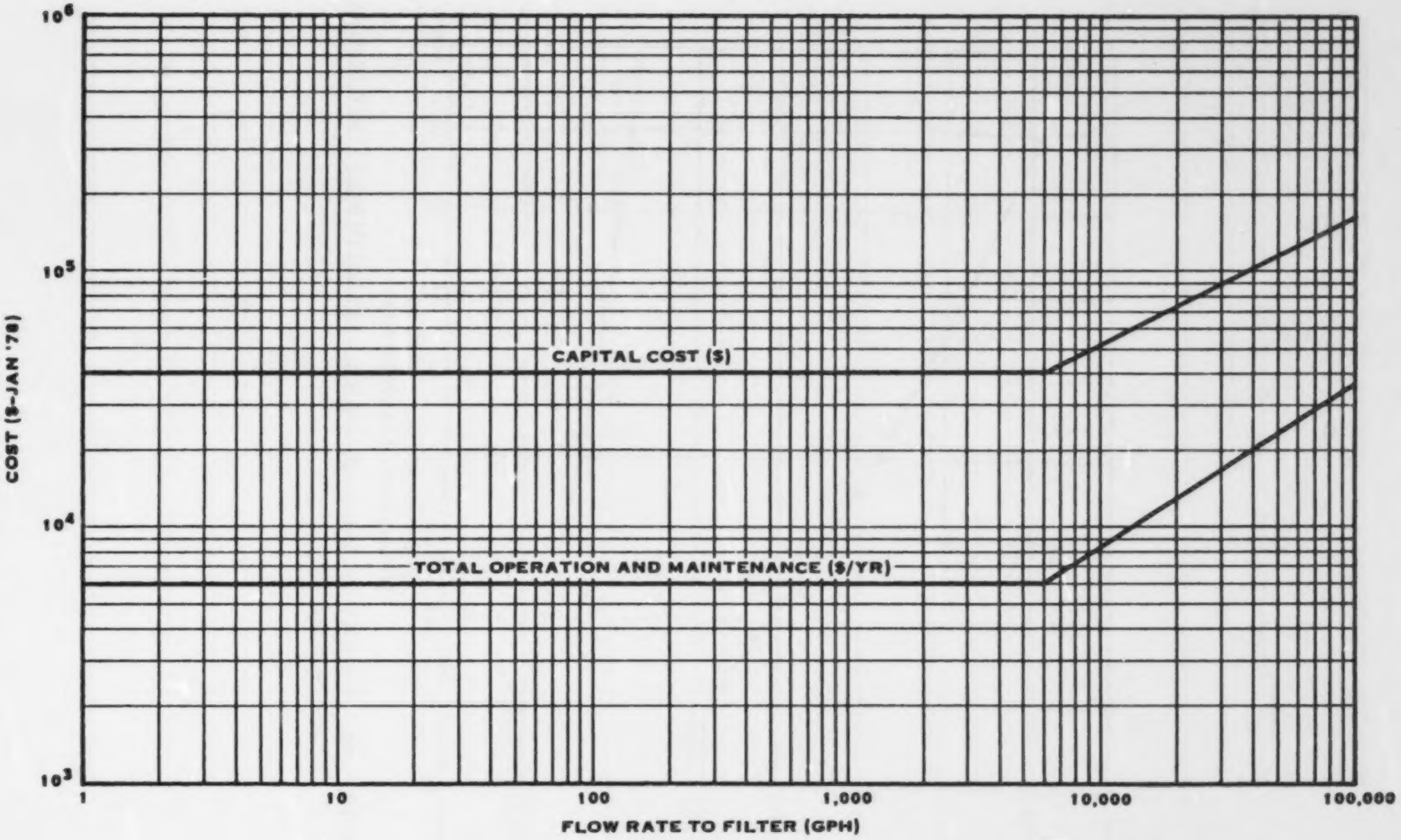


FIGURE VIII-14. MULTIMEDIA FILTER COSTS

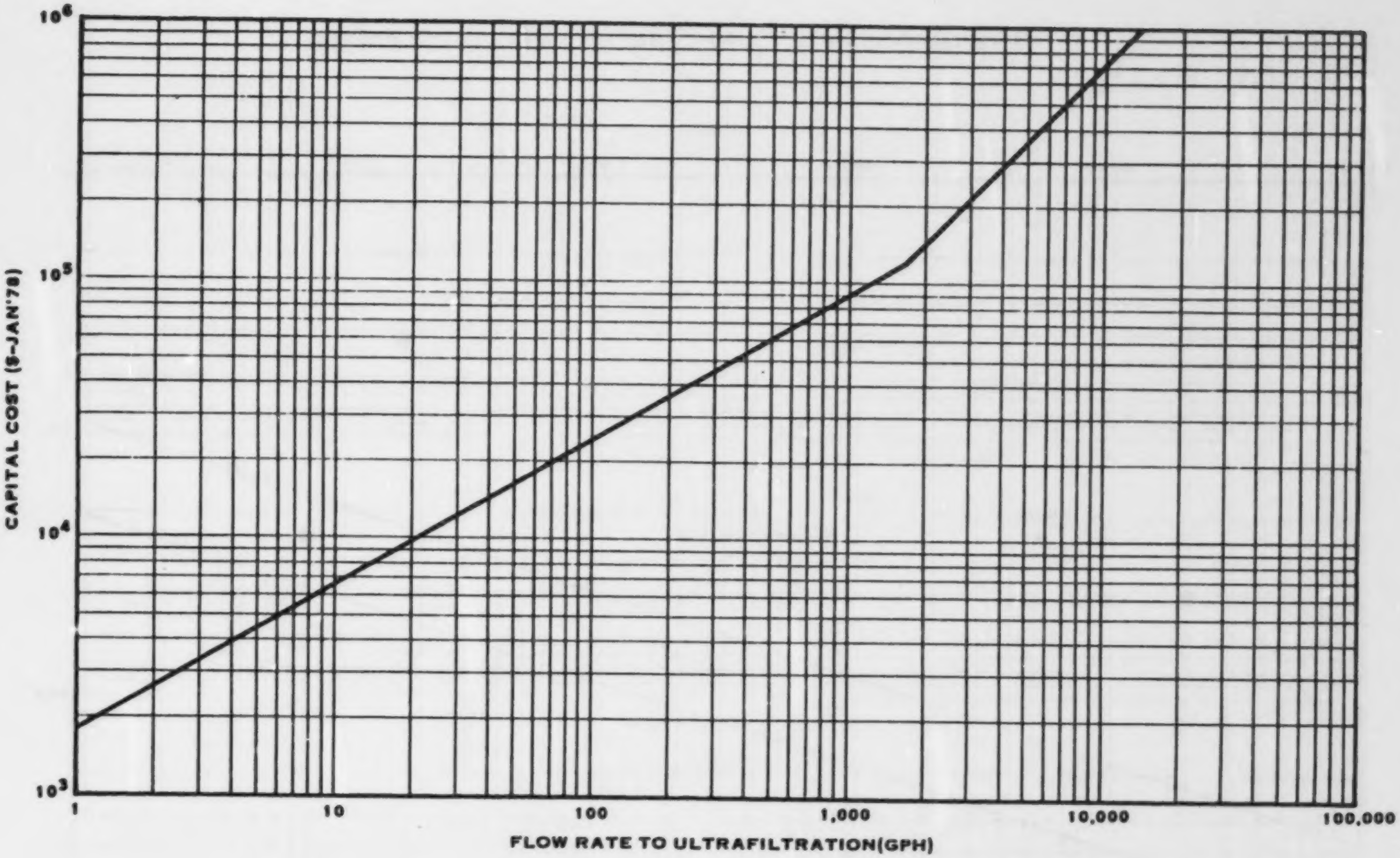


FIGURE VIII-15. ULTRAFILTRATION CAPITAL COST

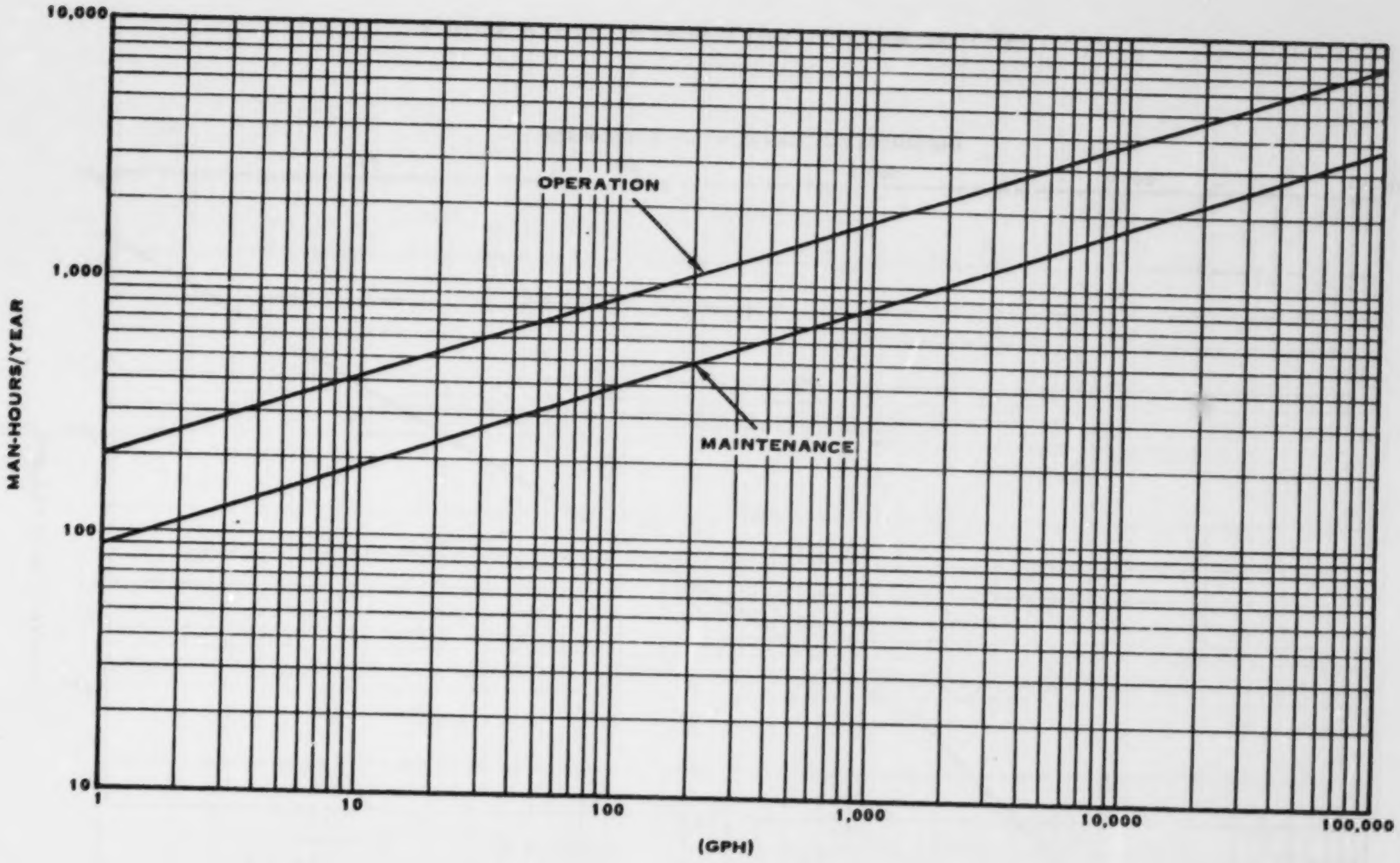


FIGURE VIII-16. ULTRAFILTRATION LABOR REQUIREMENTS

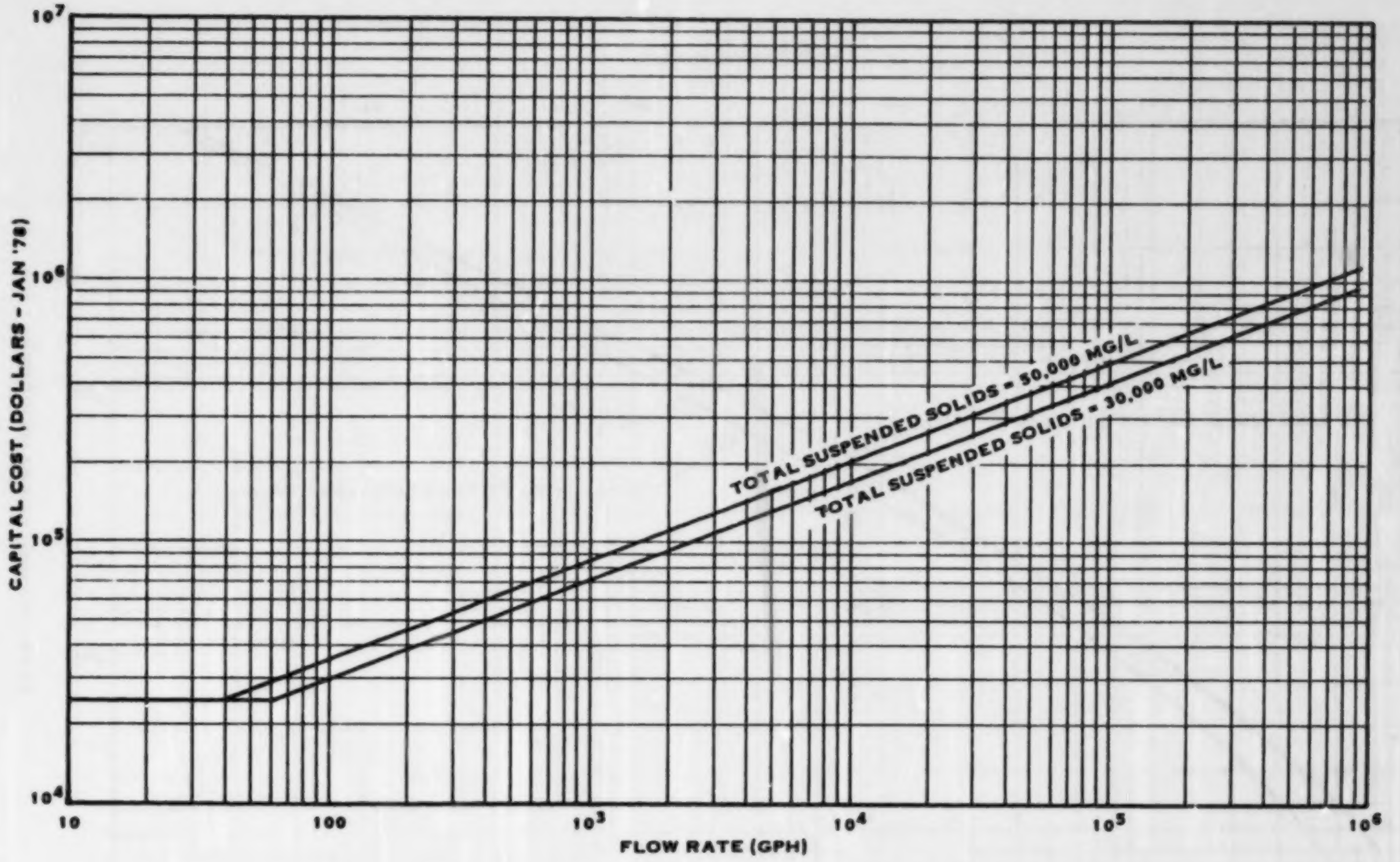


FIGURE VIII-17. VACUUM FILTRATION CAPITAL COST

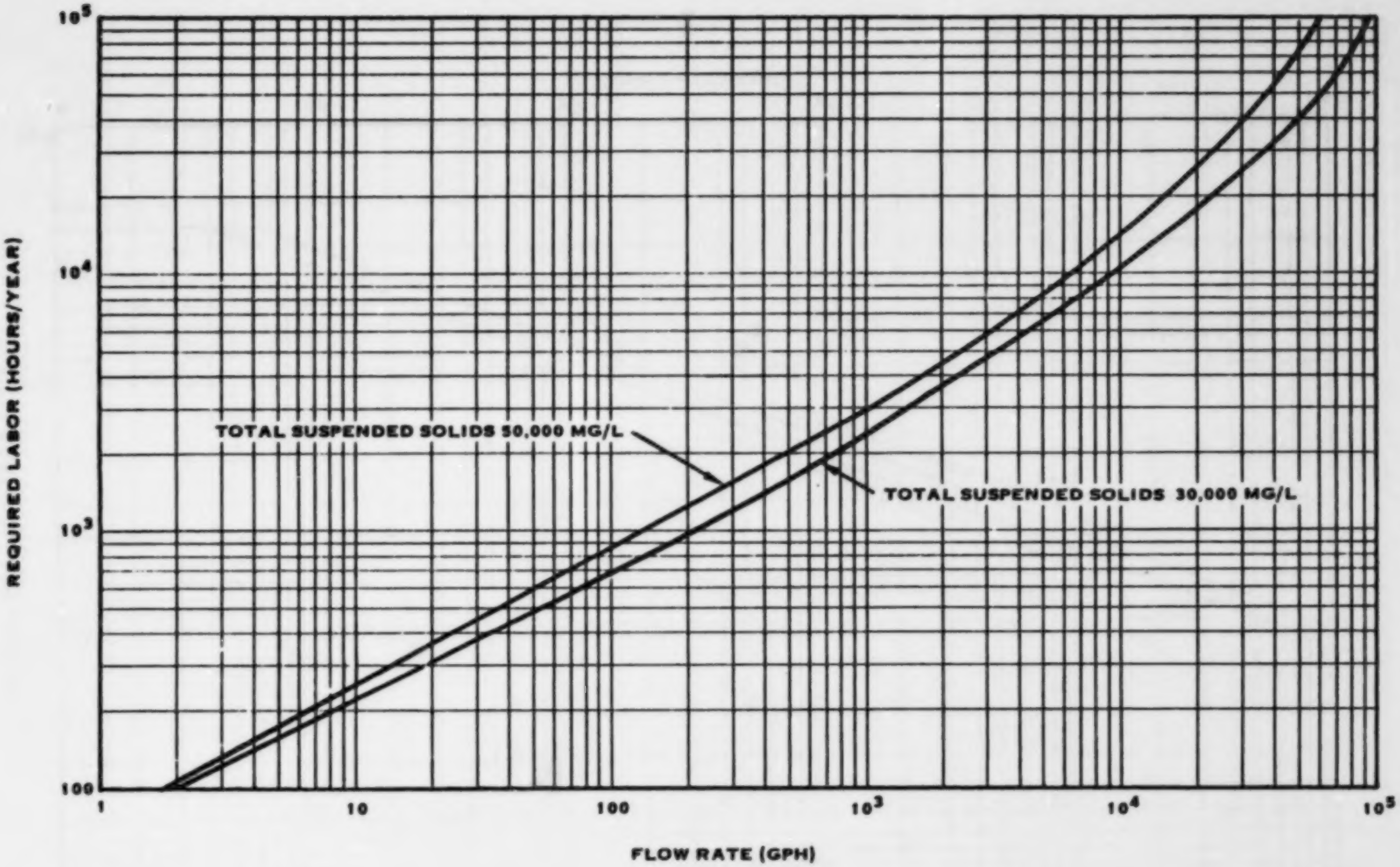


FIGURE VIII-18. VACUUM FILTRATION LABOR REQUIREMENTS

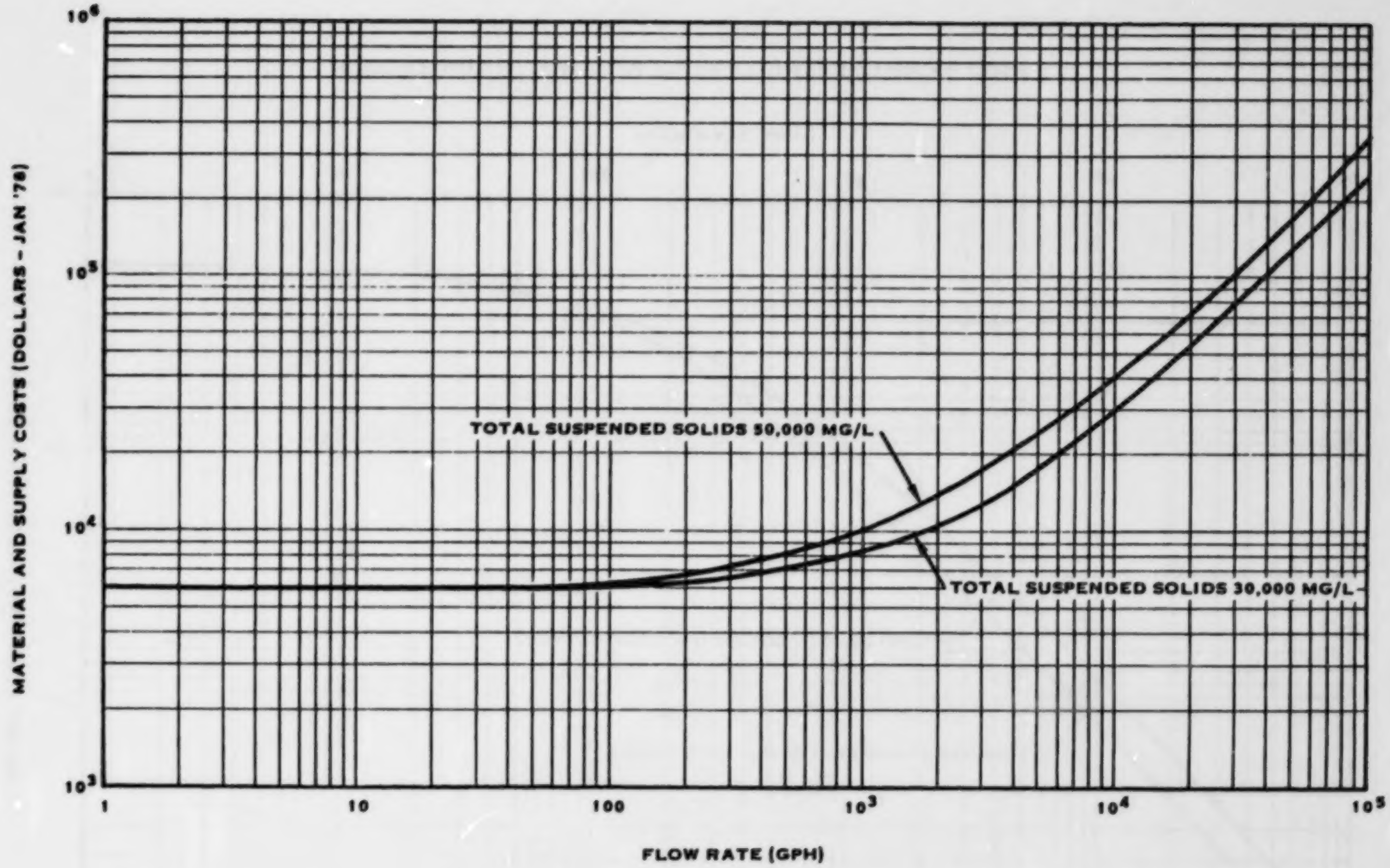


FIGURE VIII-19. VACUUM FILTRATION MATERIAL AND SUPPLY COST

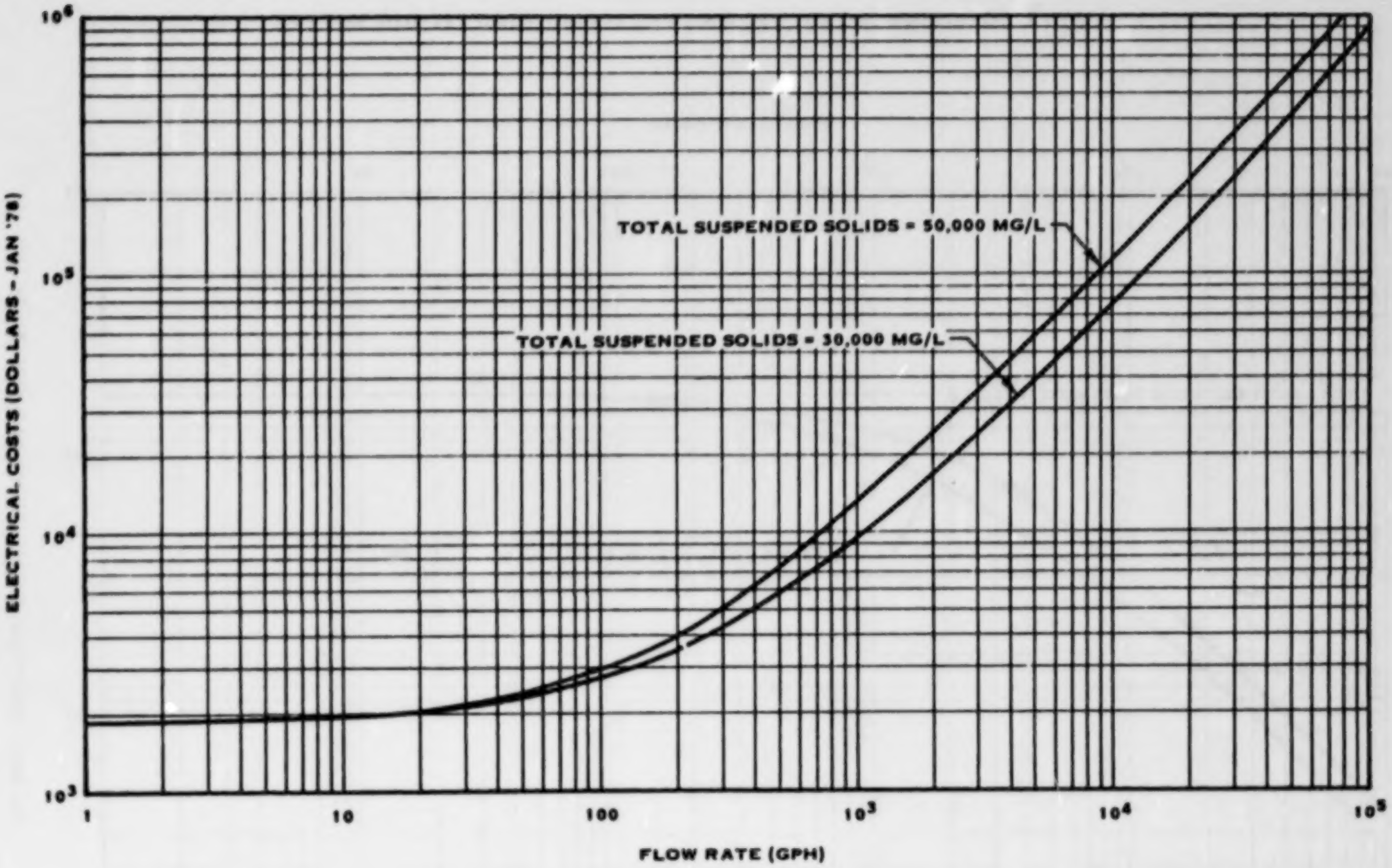


FIGURE VIII-20. VACUUM FILTRATION ELECTRICAL COST

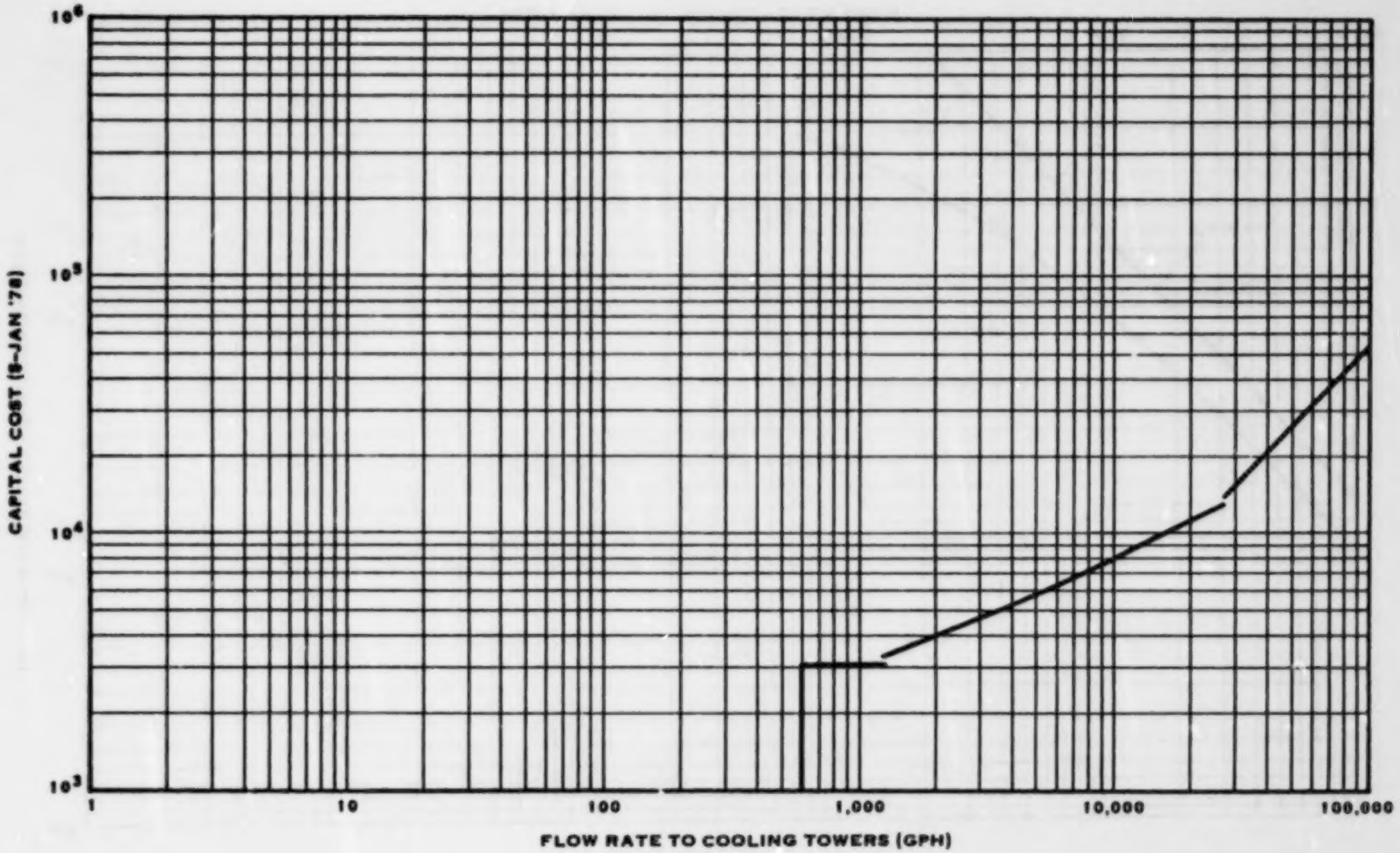


FIGURE VIII-21. COOLING TOWER CAPITAL COST

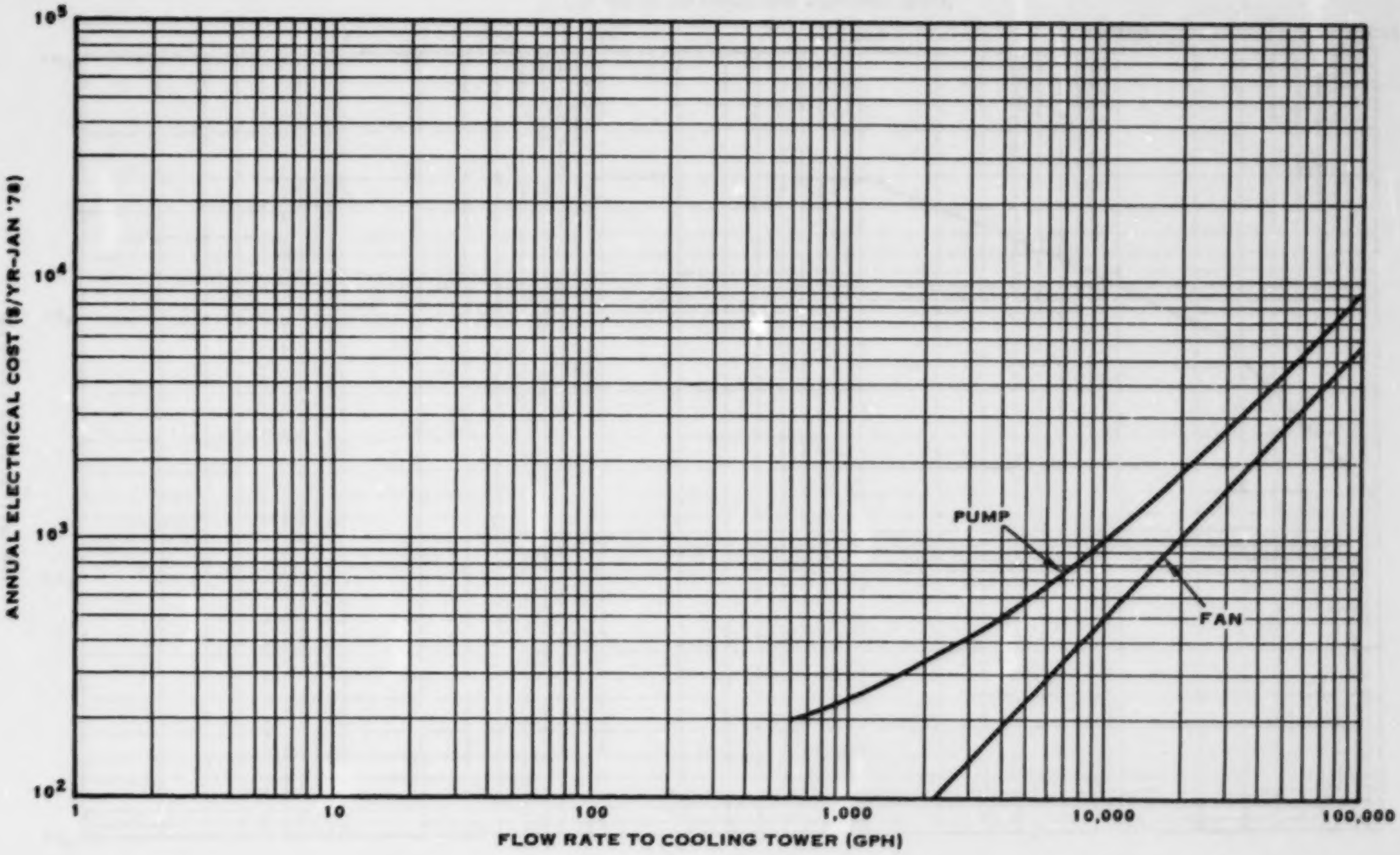


FIGURE VIII-22. COOLING TOWER ANNUAL ELECTRICAL COST

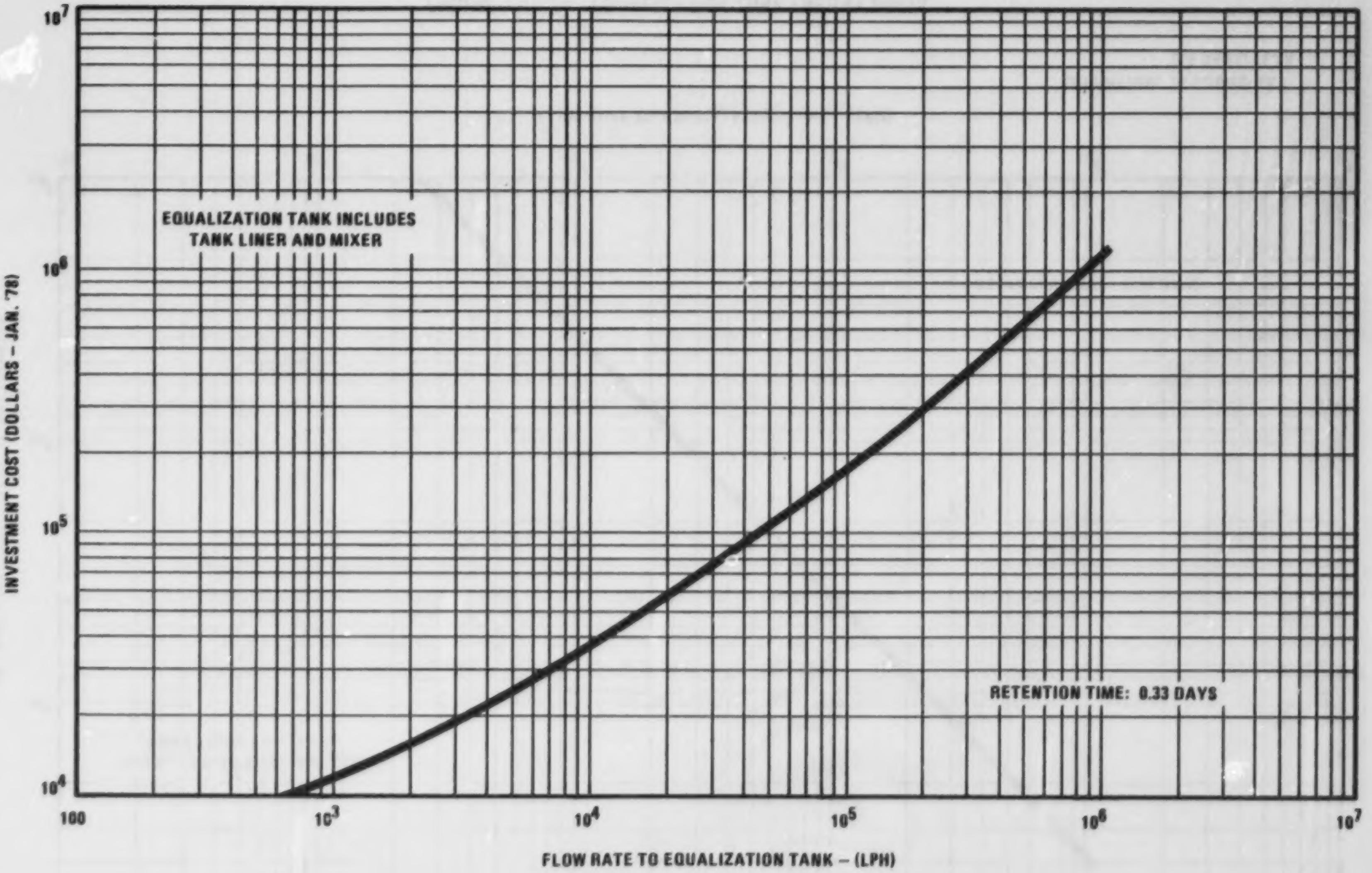
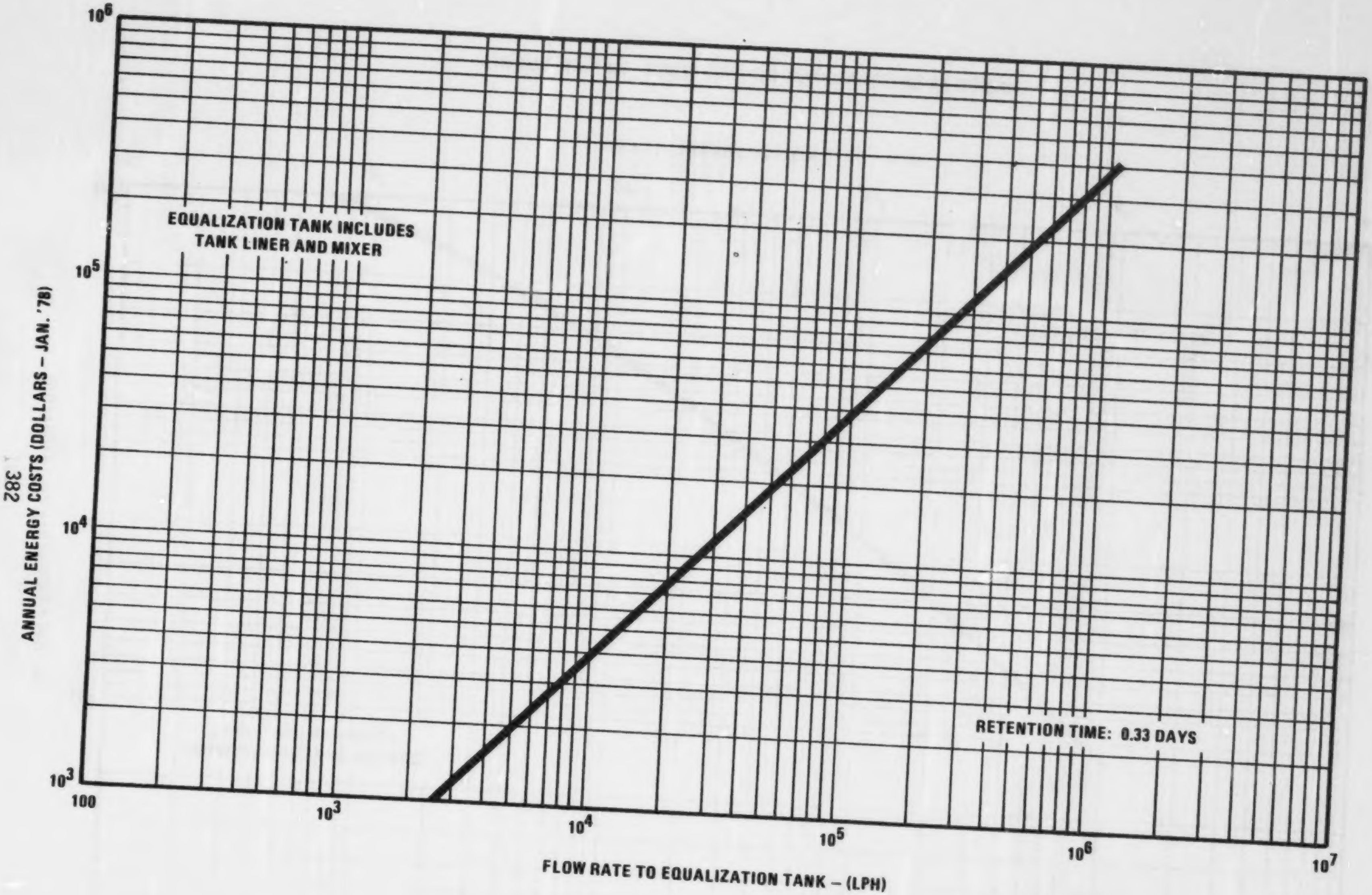


FIGURE VIII–23. EQUALIZATION TANK INVESTMENT COSTS



OPERATION: 24 HOURS/DAY
260 DAYS/YEAR

FIGURE VIII–24. EQUALIZATION TANK ENERGY COSTS

SECTION IX
BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

This section defines the effluent characteristics attainable through the application of best practicable control technology currently available (BPT). BPT reflects the performance by plants of various sizes, ages, and manufacturing processes within the three basis material subcategories.

The factors considered in defining BPT include the total cost of applying the technology in relation to the effluent reduction benefits from such application, the age of equipment and facilities involved, the process employed, non-water quality environmental impacts (including energy requirements) and other factors the Administrator considers appropriate. In general, the BPT level represents the average of the best existing performances of plants of various ages, sizes, processes or other common characteristics. Where existing performance is uniformly inadequate, BPT may be transferred from a different subcategory or category. Limitations based on transfer technology must be supported by a conclusion that the technology is, indeed, transferable and a reasonable prediction that it will be capable of achieving the prescribed effluent limits. See _Tanners' Council of America v. Train_. BPT focuses on end-of-pipe treatment rather than process changes or internal controls, except where such are common industry practice.

TECHNICAL APPROACH TO BPT

EPA first studied the coil coating operations to identify the processes used and the wastewaters generated during coil coating. Information was collected through previous work, dcp forms and specific plant sampling and analysis. The Agency used this data to subcategorize the operations and to determine what constituted an appropriate BPT. Some of the salient considerations are:

> The cleaning step of coil coating removes oil, dirt and oxide coating, and generates alkaline or acid wastewaters containing oils, dissolved metals and suspended solids.
>
> The conversion coating and sealing wastewater generally is acid in nature and contains dissolved metals, and suspended solids.

Quench wastewater which derives from cooling the paint surface after drying typically is slightly alkaline and contains small amounts of organics and suspended solids.

Of the 69 plants for which data was received: 49 have hexavalent chromium reduction, 6 have cyanide treatment, 20 have oil skimming, 37 use chemical precipitation, 42 have sedimentation by tank, lagoon, clarifier or tube or plate settlers and 32 have sludge dewatering to assist in sludge disposal.

This document has already discussed some of the factors which must be considered in establishing effluent limitations based on BPT. The age of equipment and facilities and the processes employed were taken into account in subcategorization and are discussed fully in Section IV. Nonwater quality impacts and energy requirements are considered in Section VIII.

Coil coating consists of three different sets of processes - metal preparation, conversion coating, and painting. These generate different wastewater streams. As Table IX-1 (page 393) shows, the chemical makeup of these wastewaters is distinctly different. In all three wastewater streams, as discussed in Sections III and IV, the volume of wastewater is related to area of material processed.

Cyanide compounds are used in some conversion coating formulations applied to aluminum strip. This fact is reflected in the high cyanide concentrations in rinse waters from aluminum conversion coating. Although cyanides are not commonly used in conversion coating formulations applied to steel and galvanized strip, appreciable concentrations of cyanide appeared in the conversion coating rinse streams from plants in the galvanized subcategory which also coated steel and aluminum strip. Apparently, cyanide from aluminum conversion coating operations is not readily eliminated from the rinse system when the production line is changed over to other metals. Therefore, cyanide removal by precipitation is selected for conversion coating dumps and rinses from all three subcategories.

The general approach to BPT for this category is to treat all wastewaters in a single (combined) treatment system. Normal practice is to combine wastewater for treatment because it is less expensive. Oil which is removed from the strip during alkaline cleaning must be removed from the wastewater, cyanide from conversion coating operations must be treated, and hexavalent chromium must be reduced to the trivalent state so that it can be precipitated and removed along with other metals. The dissolved metals must be precipitated and suspended solids, including the metal precipitate, removed. Segregation and separate treatment of conversion coating wastewaters is necessary to provide effective removal of cyanide and reduction of hexavalent chromium. Therefore, the strategy for BPT is to treat cyanide and reduce hexavalent chromium in conversion coating wastewaters; combine all wastewater streams and apply oil skimming to remove oil and grease and some organics; and follow or combine with lime and settle technology to remove metals and solids from the combined wastewaters. (See Figure IX-1, page 400). Some slight modification may be necessary in specific subcategories but the overall treatment strategy is applicable throughout this category. Although flows of wastewater differ from subcategory to subcategory and result in different mass limitations for each subcategory, the same treatment is applicable and equally effective on all subcategory wastewater streams.

Most of the coil coating plants sampled by EPA appear to have elements of the proposed BPT system already in place; however, observations by sampling teams and results of effluent analyses (presented in each subcategory) suggest that most treatment systems are not properly operated. Hardware systems are in-place, but operating instructions are not consistently or adequately followed. The result is universally inadequate treatment system effectiveness for the category. Treatment effectiveness data must therefore be transferred. Some plant sampling days for this category show performance equivalent to that of the combined metals data base as shown in Tables V-33, 35 and 37 which demonstrates the appropriateness of using the larger treatment effectiveness data base compiled from a number of categories with similar wastewater. Data from 11 coil coating plants are included in the combined metals data base.

SELECTION OF POLLUTANT PARAMETERS FOR REGULATION

The pollutant parameters selected for regulation in the coil coating category were selected because of their frequent presence at treatable concentrations in wastewaters from the three subcategories. In addition to oil and grease, TSS, and pH, metals are regulated in each subcategory. Also cyanide is regulated in each subcategory with an exemption procedure provided. If a plant demonstrates and certifies that it neither has nor uses cyanide in its processes and will not initiate such use, it may be exempt from the requirement of monitoring cyanide. This procedure is a change from the proposal. Table VII-21 (page 271) summarizes the BPT treatment system effectiveness for all pollutant parameters regulated in the coil coating category.

The importance of pH control is stressed in Section VII and its importance for metals removal cannot be overemphasized. Even small excursions away from the optimum level can result in less than optimum functioning of the system. Study of plant effluent data presented for each subcategory shows the importance of pH. The pH level may shift slightly from the optimum range (8.7 - 9.2) if wastewater composition differs appreciably from that of wastewaters studied. Therefore, the regulated pH is specified to be within a range of 7.5 - 10.0 (instead of 6.0 - 9.0) to accommodate the optimum level without the necessity for a final pH adjustment.

STEEL SUBCATEGORY

The BPT treatment train for steel subcategory wastewater consists of chromium reduction and cyanide removal for the segregated wastewaters from the conversion coating operation; mixing and pH adjustment, with lime or acid, of the combined wastewaters to precipitate metals; oil skimming to remove oil and grease and organics; and settling to remove suspended solids and precipitated metals.

Wastewater generated in the steel subcategory was calculated from all dcp data because dcp responses provide a more extensive data base than visited plants. Production normalized mean water use for the steel subcategory is 2.752 l/sq m processed area as set forth in Table V-12 (page 84) which is 93 percent of the proposed wastewater allowance.

Plants with production normalized flows significantly above the mean flow used in calculating the BPT limitations will need to reduce these flows to meet the BPT limitations. This reduction can usually be made at no significant cost by correcting obvious excessive water use practices (such as leaking rinse tanks) or by shutting off flows to rinses when they are not in use and installing flow control valves on rinse tanks. Specific water conservation practices applicable to reducing excess water are detailed in Section VII.

The typical characteristics of wastewaters from the cleaning and conversion coating operations in the steel subcategory, and for quench operations for the coil coating category are given in Tables V-28, V-29, and V-30 (pages 100, 101, and 102). Typical characteristics of total raw wastewater for the steel subcategory are given in Table V-31 (page 103). Table VI-1 (page 174) lists the non-conventional pollutants that were considered in setting effluent limitations for this subcategory. Regulated pollutants at BPT include chromium, cyanide, zinc, iron, oil and grease, TSS, and pH, cadmium, copper, lead and nickel, proposed for regulation, are not included at promulgation. Other pollutants listed, in Table VI-1 are not specifically regulated at BPT. However, if the regulated pollutants are removed to the appropriate levels, the other pollutants will be adequately removed coincidentally. Lime and settle technology combined with oil skimming should reduce the concentration of regulated pollutants to the levels described in Table VII-21.

When these concentrations are applied to the dcp mean wastewater flow described above, the mass of pollutant allowed to be discharged per unit area prepared and coated can be calculated. Table IX-2 (page 394) shows the limitations derived from this calculation. Total wastewater values are based on a typical coil coating operation where the strip is cleaned, conversion coated, and painted once.

The derivation of one limitation is presented below in reverse order so that the individual numerical steps in arriving at the limitations can be seen. The steel subcategory BPT maximum for any one day for chromium is 1.156 mg/m². This number is the product of the one day maximum chromium concentration for lime and settle treatment which is 0.42 mg/l, (Table VII-21) and the mean dcp steel subcategory water use which is 2.752 l/m² (Table V-12). The one day maximum chromium value was developed in Section VII. The mean water use is the mean of the steel subcategory water uses (presented in Table V-6). Each of these individual water uses was calculated by dividing the yearly water used in a plant by the total production (two sides of coil) for that year (dcp's and Section V). At proposal, the median production normalized flow was used as the regulatory flow. the Agency is using the mean rather than the median for the production normalized flow because the mean more accurately characterizes water use practices in the category.

To determine the reasonableness of these limitations, EPA examined data for the regulated pollutant parameters from the sampled plants (Table IX-3, page 395) to determine how many plants were meeting this BPT. These data indicate that, no plants were meeting all the BPT mass limitations; however, values for one plant sampling day (11058-1) met all the limitations and more than half of the values from all sampling days are within the limitations for each pollutant parameter except pH and oil and grease. On four additional sampling days (11055-1, 36056-1, 36056-2 and 36056-3), all but one of the values were within the proposed limitation on each day. Viewed as a group, the 34 effluent values for the five sampling days with best performance (including three plants) included only 4 values outside the limitations 2 for oil and grease and 2 for pH. Of particular note is the fact that all 15 metals values were within the limitations and that all pH values were 8.0 or greater.

EPA also examined the effect of pH on the sampled plants' data. On one plant sampling day (46050-1) where TSS limitations were met, but where the pH was below 7.5, all 3 of the regulated metals values exceeded the limitations. On two other plant sampling days (11058-2 and 12052-2) where TSS values were at least double the limitation and where the pH was below 7.5 all 5 of the reported values for regulated metals exceeded the limitations. Correction of the pH to a more normal level in the range of 7.8 to 8.3 would be expected to bring the plant performances into conformance with the BPT Limitations.

Proposed oil and grease limitations can be met with properly operated oil skimmers, and proposed metals and TSS limitations can be met with pH adjustment and settling. Table VII-11 demonstrates that oil skimming can remove oil and grease to the regulated levels. The need for close pH control is illustrated by the effluent data. When pH falls below the lower limit, metals are not removed. At pH's above the upper limit,metals that became soluble as oxygenated anions return to solution. Therefore, the promulgated limitations (Table IX-2) for the steel subcategory are reasonable.

In the establishment of BPT, the cost of application of technology must be considered in relation to the effluent reduction benefits from such application. The quantity of pollutants removed by BPT is displayed in Table X-17 (page 425) and the total cost of application of BPT is shown in Table X-18 (page 426). The capital cost of BPT as an increment above the cost of in-place treatment equipment is estimated to be $2,321,000 for the steel subcategory. Annual cost of BPT for the steel subcategory is estimated to be $858,000. The quantity of pollutants removed by the BPT system for this subcategory is estimated to be 233,889 kg/yr, including 6,690 kg/yr of toxic pollutants. The effluent reduction benefit is worth the dollar cost of required BPT.

GALVANIZED SUBCATEGORY

The BPT treatment train for galvanized subcategory wastewater consists of chromium reduction and cyanide removal for the segregated wastewaters from the conversion coating operation; mixing and pH adjustment of the combined wastewaters with lime or acid to precipitate metals; oil skimming to remove oil and grease and some organics; and settling to remove suspended solids and precipitated metals.

Wastewater generated in the galvanized subcategory was calculated from all dcp data because dcp responses provide a more extensive data base than visited plants. Production normalized mean water use for the galvanized subcategory is 2.610 l/sq m processed area as set forth in Table V-12 (page 84) which is 78 percent of the proposed wastewater allowance.

Plants with production normalized flows significantly above the mean flow used in calculating the BPT limitations will need to reduce these flows to meet the BPT limitations. This reduction can usually be made at no significant cost by correcting obvious excessive water use practices (such as leaking rinse tanks) or by shutting off flows to rinses when they are not in use and installing flow control values on rinse tanks. Specific water conservation practices applicable to reducing excess water are detailed in Section VII.

The typical characteristics of wastewaters from the cleaning and conversion coating operations in the galvanized subcategory, and for quench operations for the total coil coating category are shown in Tables V-28, V-29, V-30. Typical characteristics of total raw wastewater for the galvanized subcategory are in Table V-31. Tables VI-2 and VI-4 list the pollutants that were considered in setting effluent limitations for this subcategory. Regulated pollutants at BPT include chromium, copper, cyanide, zinc, iron, oil and grease, TSS, and pH, cadmium, lead, and nickel, proposed for regulation, are not included at promulgation. Other pollutants listed in Table VI-2 and VI-4 are not specifically regulated at BPT. However, if the regulated pollutants are removed to the appropriate levels, the other pollutants will be adequately removed coincidentally. The combination of lime and settle technology with oil skimming should reduce the concentration of regulated pollutants to the levels described in Table VII-21.

When these concentrations are applied to the dcp mean wastewater flow described above, the mass of pollutant allowed to be discharged per unit area prepared and coated can be calculated. Table IX-4 shows the limitations derived from this calculation. Total wastewater values are based on a typical coil coating operation where the strip is cleaned, conversion coated, and painted once.

To determine the reasonableness of these limitations, EPA examined data for regulated pollutant parameters from the sampled plants (Table IX-5, page 397) to determine how many plants were meeting this BPT. Values for three sampling day (11058-1, 33056-1 and 33056-2) met all limitations; values for one additional sampling day (38053-1) met all limitations except pH; a third sampling days (38053-3 and 46050-3) had pH and one metal value outside of the limitation. Thus for six sampling days with 48 reported values for regulated pollutant parameters, only 4 of the values, including 2 pH values, exceeded the limitations. TSS was 31.72 mg/sq m or less, showing effective solids removal. The remaining eight sampling days with 64 reported values for regulated metals can be examined in two groups of four and one group (36058-2, 38053-2, 46050-2, and 46050-3) with 12 metals values had low pH for each sampling day and 7 metal values exceeded the limitation. The second group (11058-2, 12052-1, 12052-2, and 12052-3) had TSS values from 2 times the limitations and all 11 reported values for regulated metals exceed the limitations. Correction of the pH to a more normal level in the range of 7.8-8.3 would be expected to bring plant performances into conformance with the BPT limitations.

Oil and grease limitations can be met with properly operated oil skimmers (see Table VII-11) and metals and TSS limitations can be met with pH adjustment and settling. The need for close pH control is illustrated by the effluent data. When pH falls below the lower limit, metals are not removed. At pH's above the upper limit, metals that become soluble as oxygenated anions return to solution. Therefore, the promulgated limitations (Table IX-4) for the galvanized subcategory are reasonable.

In the establishment of BPT, the cost of applying a technology must be considered in relation to the effluent reduction benefits achieved by such application. The quantity of pollutants removed by BPT is displayed in Table X-17 and the total cost (1978 dollars) of application of BPT is shown in Table X-18. The capital cost of BPT as an increment above the cost of in-place treatment equipment is estimated to be $231,000 for the galvanized subcategory. Annual cost of BPT for the galvanized subcategory is estimated to be $86,000. The quantity of pollutants removed above raw waste by the BPT system for this subcategory is estimated to be 121,720 kg/yr, including 7,484 kg/yr of toxic pollutants. EPA believes that the effluent reduction benefit outweighs the dollar cost of required BPT.

ALUMINUM SUBCATEGORY

The BPT treatment train for aluminum subcategory wastewater consists of chromium reduction and cyanide precipitation for the segregated wastewaters from the conversion coating operation; mixing and pH adjustment of the combined wastewaters with lime or acid to precipitate metals; oil skimming to remove oil and grease plus some organics; and settling to remove suspended solids plus precipitated metals.

Wastewater generated in the aluminum subcategory was calculated from all dcp data because dcp responses provide a more extensive data base than visited plants. Production normalized mean water use for the aluminum subcategory is 3.363 l/sq m processed area as set forth in Table V-12 (page 84) which is 117 percent of the proposed wastewater allowance.

Plants with production normalized flows significantly above the mean flow used in calculating the BPT limitations will need to reduce flows to meet the BPT limitations. This reduction can usually be made at no significant cost by correcting obvious excessive water use practices (such as leaking rinse tanks) or by shutting off flows to rinses when they are not in use and installing flow control valves on rinse tanks. Specific water conservation practices applicable to reducing excess water are detailed in Section VII.

The typical characteristics of wastewaters from the cleaning and conversion coating operations in the aluminum subcategory, and from quench operations for the total coil coating category are shown in Tables V-28, V-29, and V-30. Typical characteristics of total raw wastewater for the aluminum subcategory are in Table V-31. Tables VI-3 and VI-4 list the pollutants that should be considered in setting effluent limitations for this subcategory. The regulated pollutants at BPT include chromium, cyanide, zinc, aluminum, oil and grease, TSS and pH, lead, cadmium, copper, nickel and iron, proposed for regulation, are not included at promulgation. Other pollutants listed in Table VI-3 and VI-4 are not specifically regulated at BPT. However, if the regulated pollutants are removed to the appropriate levels, the other pollutants will be adequately removed coincidentally. The combination of lime and settle technology with oil skimming should reduce the concentration of regulated pollutants to the levels described in Table VII-21. The pH must be maintained within the range 7.5 - 10.0 at all times.

When these concentrations are applied to the dcp mean wastewater flow described above, the mass of pollutants allowed to be discharged per unit area prepared and coated can be calculated. Table IX-6 shows the limitations derived from this calculation. Total wastewater values are based on a typical coil coating operation where the strip is cleaned, conversion coated, and painted once.

To determine the reasonableness of these limitations, EPA reviewed the data for regulated pollutant from the sampled plants

(Table IX-7, page 379) to determine how many plants were meeting this BPT. The effluent values for all pollutant parameters with within the limitations for one sampling day (01054-3) and all parameters except pH were within the limitations on two sampling days (01054-1 and 01054-2) An additional 12 sampling days (including four plants) had 53 of 84 effluent values within the limitations. One plant (40064) had no solids removal facilities in the wastewater treatment system.

Oil and grease limitations can be met with properly operated oil skimmers (see Table VII-11) and metals and TSS Limitations can be met with pH adjustment and settling. The need for close pH control is illustrated by the effluent data. When pH falls below the lower limit, metals are not removed. At pH's above the upper limit, metals that become soluble as oxygenated anions return to solution. Therefore, the promulgated limitations (Table IX-6) for the aluminum subcategory are reasonable.

In the establishment of BPT, the cost of applying a technology must be considered in relation to the effluent reduction benefits achieved by such application. The quantity of pollutants removed by BPT is displayed in Table X-17 and the total cost of application of BPT is shown in Table X-18. The capital cost of BPT as an increment above the cost of in-place treatment equipment is estimated to be $4,429,000 for the aluminum subcategory. Annual cost of BPT for the aluminum subcategory is estimated to be $1,722,000. The quantity of pollutants removed above raw waste by the BPT system for this subcategory is estimated to be 633,138 kg/yr including 98,916 kg/yr of toxic pollutants. EPA believes that the effluent reduction benefit outweighs the dollar cost of required BPT.

TABLE IX-1

SUMMARY TABLE

UNTREATED WASTEWATER CHARACTERISTICS FOR COIL COATING CATEGORY

(Median Value)

Process Operation	Cleaning			Conversion Coating			Quenching			Combined Wastewater		
Subcategory	Steel	Galvanized	Aluminum	Steel	Galvanized	Aluminum	Steel	Galvanized	Aluminum	Steel	Galvanized	Aluminum
Flow $1/m^2$	2.274	1.368	0.964	0.421	0.528	0.546	3.632	3.632	3.632	6.33	5.53	5.14
Parameter (mg/1)												
118 Cadmium	0.004	0.040	0.003	0.006	0.010	0.008	0.014	0.014	0.014	0.001	0.045	0.004
119 Chromium	0.182	0.270	0.180	71.081	0.200	117.500	0.013	0.013	0.013	6.865	57.596	43.500
120 Copper	0.059	0.020	0.075	0.032	0.018	0.052	0.006	0.006	0.006	0.015	0.009	0.430
121 Cyanide	0.024	0.017	0.010	0.092	0.200	2.570	0.021	0.021	0.021	0.012	0.082	0.568
122 Lead	0.457	1.950	0.170	0.480	0.500	0.285	0.048	0.048	0.048	0.142	0.422	0.118
124 Nickel	0.039	0.150	0.000	6.762	4.430	0.108	0.190	0.190	0.190	0.392	0.395	0.028
128 Zinc	3.200	85.300	0.210	51.264	73.350	0.540	0.150	0.150	0.150	7.588	25.489	0.200
Toxic Organics	0.579	0.516	0.145	1.035	0.183	0.213	0.480	0.480	0.480	1.344	0.201	0.140
Aluminum	0.340	1.300	251.500	1.190	2.310	107.500	1.025	1.025	1.025	0.607	1.741	112.212
Iron	5.200	1.025	0.275	9.234	5.050	7.815	0.136	0.136	0.136	10.145	2.829	3.448
Phosphorous	42.300	32.600	90.400	43.400	25.100	14.500	0.780	0.780	0.780	42.874	14.758	7.000
Oil & Grease	261.00	107.500	75.000	6.600	10.500	2.000	5.000	5.000	5.000	341.650	52.965	57.561
TSS	256.00	162.000	49.000	133.500	190.000	55.000	5.000	5.000	5.000	152.791	114.053	84.884

TABLE IX-2
BPT EFFLUENT LIMITATIONS
STEEL SUBCATEGORY

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2	$(lb/1{,}000{,}000\ ft^2)$	mg/m^2	$(lb/1{,}000{,}000\ ft^2)$
CADMIUM	0.881	(0.180)	0.413	(0.085)
*CHROMIUM	1.156	(0.237)	0.468	(0.096)
COPPER	5.229	(1.071)	2.752	(0.564)
*CYANIDE	0.798	(0.163)	0.330	(0.068)
LEAD	0.413	(0.085)	0.358	(0.073)
NICKEL	3.880	(0.795)	2.752	(0.564)
*ZINC	3.660	(0.750)	1.541	(0.316)
*IRON	3.385	(0.693)	1.734	(0.355)
*OIL & GREASE	55.040	(11.273)	33.024	(6.764)
*TSS	112.832	(23.110)	55.040	(11.273)
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE IX-3
PRODUCTION NORMALIZED EFFLUENT MASS
STEEL SUBCATEGORY (mg/m^2)

Pollutant Parameter	Plant ID - Sampling Day												
	11055-1	11058-1	11058-2	12052-2	12052-3	36056-1	36056-2	36056-3	36058-1	36058-3	36058-4	46050-1	46050-2
Cadmium	0.011	0.00	0.00	*	*	0.00	0.00	—	0.296	—	0.00	0.00	0.00
Chromium	0.273	0.659	1.833	14.25	0.703	1.020	1.068	0.492	0.065	0.324	0.615	1.284	0.692
Cyanide	0.00	0.00	0.00	0.693	0.190	—	0.00	0.001	0.00	0.00	0.00	0.351	0.089
Lead	0.164	0.00	0.00	2.215	0.626	0.008	0.006	0.005	0.00	—	0.00	0.314	0.207
Nickel	0.176	0.00	0.00	0.385	*	0.016	*	0.00	0.00	0.00	0.00	3.622	5.30
Zinc	0.757	0.528	3.856	120.4	37.52	0.144	0.167	0.127	3.874	4.050	9.82	27.09	32.25
Iron	0.00	1.243	—	77.7	37.90	0.346	0.370	0.366	13.02	16.07	26.18	3.615	3.369
Oil & Grease	9.69	11.30	59.2	220.7	79.1	24.40	75.6	122.0	0.00	772.	115.2	150.2	107.5
TSS	46.93	32.03	225.3	376.2	305.5	46.25	107.4	68.4	667.	—	—	49.91	68.0
pH	8.0-11.1	8.3-9.5	6.9-8.6	7.4-10.8	7.1-10.0	8.5-10.8	8 0-9.0	8.0-8.9	2.0-9.1	2.7-10.7	2.7-10.7	6.7-7.3	6.7-7.3

*Possibly detected but below the detection limit.

TABLE IX-4
BPT EFFLUENT LIMITATIONS
GALVANIZED SUBCATEGORY

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2	$(lb/1,000,000\ ft^2)$	mg/m^2	$(lb/1,000,000\ ft^2)$
CADMIUM	0.835	(0.171)	0.392	(0.080)
*CHROMIUM	1.096	(0.224)	0.444	(0.091)
*COPPER	4.959	(1.016)	2.610	(0.535)
*CYANIDE	0.757	(0.155)	0.313	(0.064)
LEAD	0.392	(0.080)	0.339	(0.069)
NICKEL	3.680	(0.754)	2.610	(0.535)
*ZINC	3.471	(0.711)	1.462	(0.299)
*IRON	3.210	(0.657)	1.644	(0.337)
*OIL & GREASE	52.200	(10.691)	31.320	(6.415)
*TSS	107.010	(21.917)	52.200	(10.691)
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE IX-5
PRODUCTION NORMALIZED EFFLUENT MASS
GALVANIZED SUBCATEGORY (mg/m^2)

Pollutant	Plant ID - Sampling Day											
Parameter	11058-1	11058-2	12052-1	12052-2	12052-3	33056-1	33056-2	36058-2	38053-1	38053-2	38053-3	46050-3
Cadmium	0.00	0.00	1.389	*	*	0.00	0.044	0.00	0.00	0.00	0.00	0.00
Chromium	0.653	1.956	119.1	9.03	1.151	0.589	0.106	0.372	0.177	2.978	0.435	0.128
Copper	0.013	0.022	0.075	0.049	0.059	0.00	0.00	0.079	0.003	0.00	0.00	0.012
Cyanide	0.00	0.00	0.622	0.439	0.311	0.106	0.095	0.00	0.00	0.00	0.00	0.478
Lead	0.00	0.00	3.454	1.421	1.025	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nickel	0.00	0.00	5.212	0.244	0.025	0.082	0.00	0.00	0.00	0.007	0.035	5.53
Zinc	0.522	4.117	432.7	76.25	61.4	0.353	0.096	5.93	0.361	3.805	3.757	5.13
Iron	1.232	-	52.2	49.23	62.1	1.178	1.852	15.82	0.200	0.142	0.284	1.981
Oil & Grease	11.20	63.2	192.2	139.8	129.5	21.20	22.22	69.6	8.00	11.56	5.48	43.45
TSS	31.72	240.5	3014.	238.3	500.	7.07	21.16	-	19.35	24.00	23.47	70.02
pH	8.3-9.5	6.9-8.6	7.0-10.7	7.4-11.6	6.8-11.5	7.5-7.5	7.5-7.5	3.9-9.2	7.1-11.5	6.5-9.1	4.3-9.4	6.7-7.3

*Possibly detected but below the detection limit.

TABLE IX-6
BPT EFFLUENT LIMITATIONS
ALUMINUM SUBCATEGORY

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2	(lb/1,000,000 ft^2)	mg/m^2	(lb/1,000,000 ft^2)
CADMIUM	1.076	(0.220)	0.504	(0.103)
*CHROMIUM	1.412	(0.289)	0.572	(0.117)
COPPER	6.390	(1.309)	3.363	(0.689)
*CYANIDE	0.975	(0.200)	0.404	(0.083)
LEAD	0.504	(0.103)	0.437	(0.090)
NICKEL	4.742	(0.971)	3.363	(0.689)
*ZINC	4.473	(0.916)	1.883	(0.386)
*ALUMINUM	15.302	(3.134)	6.255	(1.281)
IRON	4.136	(0.847)	2.119	(0.434)
*OIL & GREASE	67.260	(13.776)	40.356	(8.266)
*TSS	137.883	(28.241)	67.260	(13.776)
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE IX-7
PRODUCTION NORMALIZED EFFLUENT MASS
ALUMINUM SUBCATEGORY (mg/m^2)

Pollutant Parameter	Plant ID - Sampling Day							
	01054-1	01054-2	01054-3	01057-1	01057-2	01057-3	13029-1	13029-2
Cadmium	0.00	0.00	0.00	0.00	0.025	0.045	0.00	0.00
Chromium	0.257	0.113	0.030	*	*	0.00	8.23	3.043
Cyanide	0.018	0.012	0.002	0.093	0.100	0.056	0.00	0.00
Lead	0.019	0.022	0.020	0.00	0.00	0.00	0.00	0.00
Nickel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zinc	0.135	0.648	0.966	1.275	1.365	4.068	0.819	0.201
Aluminum	0.893	0.612	0.504	17.89	45.27	40.85	11.21	5.98
Iron	0.262	0.009	0.008	0.703	0.970	0.511	0.645	0.145
Oil & Grease	0.902	2.184	0.900	19.77	26.88	55.6	26.78	29.78
TSS	46.45	35.31	3.900	14.45	87.60	51.7	127.5	45.36
pH	6.9-7.9	7.0-8.1	7.8-8.2	6.4-8.4	6.5-8.4	6.3-8.5	7.7-8.6	7.7-8.7

Pollutant Parameter	Plant ID - Sampling Day						
	13029-3	15436-1	15436-2	15436-3	40064-1	40064-2	40064-3
Cadmium	0.00	-	0.00	0.00	*	0.013	*
Chromium	11.19	0.00	3.419	2.898	283.7	519.	251.6
Cyanide	0.00	1.760	0.00	0.00	3.124	3.066	2.327
Lead	0.00	0.00	0.048	0.00	0.593	1.298	0.580
Nickel	0.00	-	0.00	0.00	0.083	0.171	0.00
Zinc	0.307	0.00	0.254	0.061	0.714	1.942	0.693
Aluminum	14.13	0.00	12.80	11.03	176.1	138.1	157.8
Iron	0.259	0.00	1.087	0.849	87.0	181.3	88.4
Oil & Grease	16.05	4.224	2.416	1.749	4.212	1.118	9.80
TSS	117.7	139.0	62.8	64.9	2256.	6717.	1931.
pH	7.7-8.5	7.2-9.0	7.2-7.5	7.7-7.7	6.3-11.2	4.9-11.3	3.4-11.9

*Possibly detected but below the detection limit.

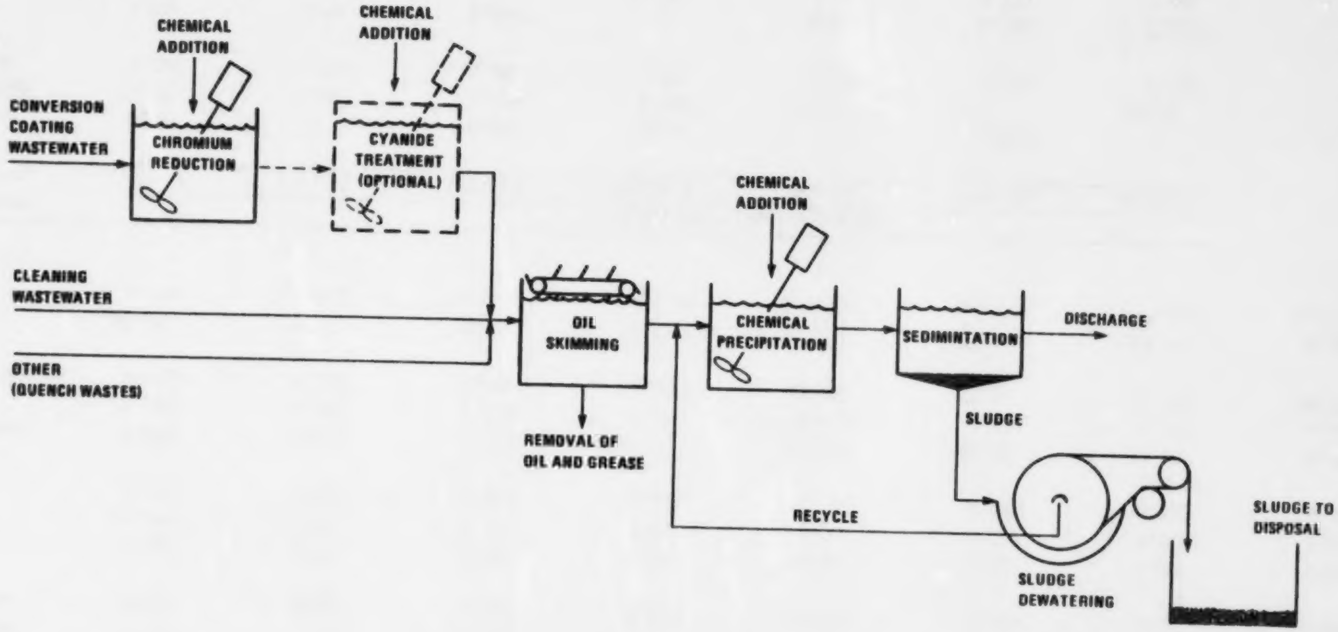

CONVERSION COATING WASTEWATER
CHEMICAL ADDITION
CHROMIUM REDUCTION
CHEMICAL ADDITION
CYANIDE TREATMENT (OPTIONAL)
CLEANING WASTEWATER
OTHER (QUENCH WASTES)
OIL SKIMMING
REMOVAL OF OIL AND GREASE
CHEMICAL ADDITION
CHEMICAL PRECIPITATION
SEDIMINTATION
DISCHARGE
SLUDGE
RECYCLE
SLUDGE DEWATERING
SLUDGE TO DISPOSAL

FIGURE IX-1. BPT WASTEWATER TREATMENT SYSTEM

SECTION X

BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

The effluent limitations in this section apply to existing direct dischargers. A direct discharger is a facility which dischargers or may discharge pollutants into waters of the United States. This section presents information on direct dischargers only as well as total category and each subcategory data.

The factors considered in assessing best available technology economically achievable (BAT) include the age of equipment and facilities involved, the process employed, process changes, non-water quality environmental impacts (including energy requirements) and the costs of application of such technology (Section 304(b)(2)(B). BAT technology represents the best existing economically achievable performance of plants of various ages, sizes, processes or other shared characteristics. As with BPT, those categories whose existing performance is uniformly inadequate may require a transfer of BAT from a different subcategory or category. BAT may include process changes or internal controls, even when these are not common industry practice.

TECHNICAL APPROACH TO BAT

In establishing BAT limitations, the Agency reviewed a wide range of technology options. These options included the range of available technologies applicable to the category and its subcategories, and suggested three technology trains which accomplish reduction in the discharge of toxic pollutants above that achieved at BPT.

As a general approach for the category, three levels of BAT were evaluated. The technologies in general are equally applicable to all the subcategories and each level produces similar concentrations of pollutants in the effluent from all subcategories. Mass limitations derived from these options, however, vary because of the impact of varying water use and wastewater generation rates. Extreme technologies such as distillation and deep space disposal were rejected *a priori* as too costly or not proven.

The Agency proposed BAT based on the following treatment technologies:

- quench water recycle through cooling tower

- quench water reuse as cleaning rinse
- rinse sensors to shut off unused flow
- hexavalent chromium reduction
- cyanide oxidation or precipitation
- oil skimming
- hydroxide precipitation and sedimentation of metals
- filtration after sedimentation
- sludge dewatering

Before proposal the Agency also considered treatment technologies which included: countercurrent rinsing, non-cyanide conversion coating, no-rinse conversion coating, and ultrafiltration rather than conventional filtration.

The Agency received comments criticizing the requirement of filters at BAT. Industry believed the difference in removal efficiency due to filtration was too small to economically justify the addition of filtration. In response to this comment, the Agency reevaluated filtration for final rule. BAT Option 1 (page 429) for the final rule included all the proposed treatment technologies except filtration after sedimentation; BAT Option 2 (page 430) included all the proposed treatment technologies.

BAT OPTION SELECTION

The selected Option is BAT 1 which consists of: recycle of quench water using cooling towers; use of blowdown from cooling towers to provide rinse water; reduction of hexavalent chromium and removal of cyanide from conversion coating rinses; combination of rinse water and treatment with lime; settling of suspended solids; skimming of oil from settling unit; and dewatering of sludge. The selected BAT will remove 700 kg/yr of toxic pollutants over the pollutant removal achieved by BPT. The economic impact analysis indicates that BAT is economically achievable.

The incremental pollutant removal benefits of BAT 2 above BAT 1 would be the removal annually of 152 kg of total toxics and 9794 kg of other pollutants (see Table X-16, page 424). Filtration therefore would result in the removal of only about 0.02 kg per day per direct discharger.

Industry Cost and Effluent Reduction Benefits of Treatment Options

An estimate of capital and annual costs for BPT, BAT 1 and BAT 2 were prepared for each subcategory as an aid to choosing the best BAT option. The capital cost of treatment technology described in place was also calculated for each subcategory using the methodology in Section VIII. Results are presented in Table X-18 (page 426). All costs are based on January 1978 dollars.

EPA used the following method to obtain cost figures. The total cost of in-place treatment equipment for each subcategory was estimated using information provided on dcps. An average cost for a "normal plant" was determined by dividing each total subcategory cost by the number of plants having operations in that subcategory. Some plants carry out operations in more than one subcategory leading to double or triple counting of the plant. Thus the sum of "normal plants" will not equal the actual number of physical plants in the category. For "Capital In Place", this procedure defines the "Normal Plant."

In developing BPT, BAT 1 and BAT 2 costs, each known coil plant was costed for the needed equipment at the appropriate flows. Multisubcategory plants were apportioned to the appropriate subcategories by production. For each subcategory, the individual plant costs were summed to obtain costs incurred by direct dischargers, indirect dischargers and total subcategory. A "normal plant" cost was calculated by dividing the total subcategory costs by the number of plants in the subcategory. The subcategory costs were summed to arrive at category costs. Results are presented in Table X-18. The capital costs are incremental costs above equipment in place. The annual costs include the operation of the equipment in place.

Pollutant reduction benefits for each subcategory were derived by (a) characterizing raw wastewater and effluent from each proposed treatment system in terms of concentrations produced and production normalized discharges (Tables X-1 through X-3, pages 409-411) for each significant pollutant found; (b) calculating the quantities removed and discharged in one year by a "normal plant" (Tables X-5 through X-7, pages 413-415); and (c) calculating the quantities removed and discharged in one year by subcategory and for the category (Tables X-8 through X-11, pages 416-419). Table X-12 (page 420) summarizes treatment performances by subcategory and by category for BPT and each BAT option showing the mass of pollutants removed and discharged by each option. Tables X-1 through X-3 and X-5 through X-12 present pollutant reduction benefits for all plants in the subcategories and the category. Tables X-13 through X-17 present pollutant reduction benefits for direct dischargers in the subcategories and the category. The pollutant reduction benefit tables for indirect dischargers are presented in Section XII. Table X-18 presents costs for normal plants, direct dischargers, indirect dischargers, subcategory totals, and category totals. All pollutant parameter calculations were based on median raw wastewater concentrations for visited plants (Table V-31, page

103). The term "toxic organics" refers to toxic organics listed in Table X-4 (page 412).

REGULATED POLLUTANT PARAMETERS

The raw wastewater concentrations from individual operations and from the subcategory total were examined to select appropriate pollutant parameters for specific regulation. In Section VI each of the toxic pollutants was evaluated and a determination was made as to whether or not to further consider them for regulation. Pollutants were not considered for regulation if they were not detected, detected at non-quantifiable levels, unique to a small number of plants, or not treatable using technologies considered. All toxic pollutants listed for further consideration are handled in this Section. Several toxic or non-conventional metal pollutants are regulated in each subcategory.

The Agency found a small amount of several toxic organic compounds (collectively referred to as total toxic organics) in coil coating wastewaters. The concentration present is 1.47 mg/l (see Table X-4, page 412). The percent removal of organics by oil skimming from five coil coating plants is presented in Section VII. The average removal of organics by oil skimming in the category is about 84 percent. This would lower concentrations of all but 4 of the toxic organics in Table X-4 to below the quantification level.

In the proposed regulation, the toxic metals selected for control included all priority pollutants and non-conventionals for which the concentration in the raw wastewater was above the treatability limit of technologies considered. Also, if one metal was below the treatability limit in one subcategory, but not in another, it was still regulated in both. This was because most coil coating plants run more than one basis material and wastewater pollutants generated in one subcategory may contaminate wastewaters from other subcategories. Industry recommended that only pH and TSS are necessary to control the effluent toxic metals and was confused that metals in the raw wastewater in some subcategories below the treatable concentration were being controlled. Based on these comments and further evaluation, EPA decided to regulate fewer toxic metals; three metals are regulated in the steel and aluminum subcategories and four in the galvanized subcategory. This decision is because at moderate alkaline pH levels (usually 8.7 to 9.2) toxic metals form very slightly soluble hydroxides. The lime and settle technology on which the coil coating limitations are based is limited by the level of residual dissolved metals and the effectiveness of solids removal. General experience and theoretical chemistry both indicate that control of a small number of key metals will result in near optimum removal of most toxic and other pollutant metals. This would also reduce the number and cost of chemical analysis required for compliance.

Some industry sources stated that cyanide is not used in cleaning formulations and is a conversion coating process chemical only in the aluminum subcategory and that a severe product quality penalty could result from total application of non-cyanide processing; therefore, a discharge of cyanide is allowed. The Agency stated at proposal that the preferred mechanism for control of cyanide is the use of non-cyanide conversion coating. A plant may be exempt from the requirement of monitoring for cyanide regularly if it demonstrates and certifies that it neither has nor uses cyanide in its processes and it will not initiate such use.

Also, for the aluminum subcategory, the pollutants regulated are the same as those expected to be regulated in aluminum forming. This is because aluminum coil coating and aluminum forming operations are often performed at the same site and this will allow co-treatment of the wastewaters. Aluminum forming effluent limitations and standards were proposed by the Agency November 22,1982, (47 FR 52626).

The metals selected for specific regulation are discussed by subcategory. The effluent limitations achieved by application of the selected BAT Option also are presented by subcategory. Hexavalent chromium is not regulated specifically because it is included in total chromium. Only the trivalent form is removed by the lime and settle technology. Therefore the hexavalent form must be reduced to meet the limitation on total chromium in each subcategory.

STEEL SUBCATEGORY

Using the model BAT system, the flow calculation assumes that quench water would be recycled and reused so that there would be no discharge directly identifiable with quench operation. The BAT wastewater flow for the steel subcategory was obtained using visited plant data as a model to determine what portion of total plant flow (all operations) is attributable to cleaning and conversion coating operations. A ratio was calcualted using the model (visited plant data) by dividing the mean flow for all operations minus the mean flow for quench by the mean flow for all operations. This ratio was then applied to mean flow for all operations as calcualted from the dcp responses to determine BAT. The dcp responses were used because they provide an extensive data base.

The visited plant mean water use for all operations in the steel subcategory as set forth in Section V is 6.33 l/sq m processed area. This flow is the sum of 3.632 l/sq m in the quench operation, 2.274 l/sq m in cleaning, and 0.421 l/sq m in the conversion coating operation as set forth in Section V. The dcp mean water use for all operations in the subcategory as set forth in Section V is 2.752 l/sq m. The wastewater allowance for the subcategory would then become 1.173 l/sq m which is 97 percent of the proposed wastewater allowance. This flow will be used to calculate expected performance for BAT in the steel subcategory.

Pollutant parameters selected for regulation at BAT are: chromium, cyanide, zinc, and iron. The end-of-pipe treatment applied to the reduced flow would produce the effluent concentrations of regulated pollutants shown in Section VII, Table VII-21 the tabulation for precipitation and sedimentation (lime and settle) technology.

When these concentrations are applied to the plant flows described above, the mass of pollutant allowed to be discharged per unit area of steel coil cleaned and conversion coated can be calculated. Table X-19 shows the limitations derived from this calculation. The non-regulated pollutants listed in Table X-19 which were proposed for regulation will be adequately removed coincidentally if the regulated pollutants are removed to the apporpriate levels. The derivation of limitations is explained in Section IX (page 383). The BAT mean production normalized flows are derived for each subcategory in this section.

GALVANIZED SUBCATEGORY

Using the model BAT system, the flow calculation assumes that quench water would be recycled and reused so that there would be no discharge directly identifiable with quench operation. The BAT wastewater flow for the galvanized subcategory was obtained using visited plant data as a model to determine what portion of total plant flow (all operations) is attributable to cleaning and conversing coating operations. A ratio was calcualted using the model (visited plant data) by dividing the mean flow for all operations minus the mean flow for quench by the mean flow for all operations. This ratio was then from the dcp responses to determine BAT. The dcp responses were used because they provide a more extensive base.

The visited plant mean water use for all operations in the galvanized subcategory as set forth in Section V is 5.53 l/sq m processed area. This flow is the sum of 3.632 l/sq m in the quench operation, 1.368 l/sq m in cleaning, and 0.528 l/sq m in the conversion coating operation as set forth in Section V. The dcp mean water use for all operations in the subcategory as set forth in Section V is 2.610 l/sq m. The wastewater allowance for the subcategory would then become 0.896 l/sq m which is 74 percent of the proposed wastewater allowance. This flow will be used to calculate expected performance for BAT in the galvanized subcategory.

Pollutant parameters selected for regulation in the galvanized subcategory at BAT are: chromium, copper, cyanide, and iron. The end-of-pipe treatment applied to the reduced flow would produce the effluent concentrations of regulated pollutants shown in Section VII, Table VII-21 for precipitation and sedimentation (lime and settle) technology.

When these concentrations are applied to the plant flows described above, the mass of pollutant allowed to be discharged per unit area of galvanized coil cleaned and conversion coated can be calculated. Table X-20 shows the limitations derived from this calculation. The non-regulated pollutants listed in Table X-20 which were proposed for regulation will be adequately removed coincidentally if the regulated pollutants are removed to the appropriate levels.

ALUMINUM SUBCATEGORY

Using the model BAT system, the flow calculation assumes that quench water would be recycled and reused so that there would be no discharge directly identifiable with quench operation. The BAT wastewater flow for the aluminum subcategory was obtained using visited plant data as a model to determine what portion of total plant flow (all operations) is attributable to cleaning and conversion coating operations. A ratio was calculated using the model (visited plant data) by dividing the mean flow for all operations minus the mean flow for quench by the mean flow for all operations. This ratio was then applied to mean flow for all operations as calculated from the dcp responses to determine BAT. The dcp responses were used because they provide a more extensive base.

The visited plant mean water use for all operations in the aluminum subcategory as set forth in Section V is 5.14 l/sq m processed area. This flow is the sum of 3.632 l/sq n in the quench operaion, 0.964 l/sq m in cleaning, and 0.546 l/sq m in the conversion coating operatio as set forth in Section V. The dcp mean water use for all operations in the subcategory as set forth in Section V is 3.363 l/sq m. The wastewater allowance for the subcategory would then become 0.987 l/sq m which is 101 percent of the proposed wastewater allowance. This flow will be used to calculate expected performance for BAT in the aluminum subcategory.

Pollutant parameters selected for regulation in the aluminum subcategory at BAT are: chromium, cyanide, zinc, and aluminum. The end-of-pipe treatment applied to the reduced flow would produce the effluent concentrations of regulated pollutant shown in Section VII, Table VII-21 for precipitation and sedimentation (lime and settle) technology.

When these concentrations are applied to the plant flows described above, the mass of pollutant allowed to be discharged per unit area of aluminum coil cleaned and conversion coated can be calculated. Table X-21 shows the limitations derived from this calculation. The non-regulated pollutants listed in Table X-21 which were proposed for regulation will be adequately removed coincidentally if the regulated pollutants are removed to the specified levels.

DEMONSTRATION STATUS

No sampled coil coating plants in any subcategory use the BAT technology in its entirety. However, each element of the system is demonstrated in the category. The BAT model system has the same end-of-pipe treatment as BPT. In addition, BAT includes quench water recycle through a cooling tower and reuse as cleaning rinse. Of the 69 plants for which data was received: 15 have cooling towers, 19 recycle quench water, and 5 reuse quench water. The dissolved solids concentration of quench water does not increase significantly over influent concentrations; therefore, there should be no problem in using quench recycle and reuse at all coil coating facilities.

TABLE X-1
SUMMARY OF TREATMENT EFFECTIVENESS
STEEL SUBCATEGORY

PARAMETER	RAW WASTE		BPT (PSES 0)		BAT 1 (PSES 1)		BAT 2 (PSES 2)	
	mg/1	mg/m^2	mg/1	mg/m^2	mg/1	mg/m^2	mg/1	mg/m^2
FLOW $1/m^2$		2.752		2.752		1.173		1.173
118 CADMIUM	0.001	0.003	0.001	0.003	0.002	0.002	0.002	0.002
119 CHROMIUM	6.865	18.892	0.080	0.220	0.080	0.094	0.070	0.082
120 COPPER	0.051	0.140	0.051	0.140	0.119	0.140	0.119	0.140
121 CYANIDE	0.012	0.033	0.012	0.033	0.028	0.033	0.028	0.033
122 LEAD	0.142	0.391	0.120	0.330	0.120	0.141	0.080	0.094
124 NICKEL	0.392	1.079	0.392	1.079	0.570	0.669	0.220	0.258
128 ZINC	7.588	20.882	0.300	0.826	0.300	0.352	0.230	0.270
TOXIC ORG.	1.282	3.528	0.038	0.105	0.038	0.045	0.038	0.045
IRON	10.145	27.919	0.410	1.128	0.410	0.481	0.280	0.328
PHOSPHORUS	42.874	117.989	4.080	11.228	4.080	4.786	2.720	3.191
OIL & GREASE	341.650	940.221	10.000	27.520	10.000	11.730	10.000	11.730
TSS	152.790	420.478	12.000	33.024	12.000	14.076	2.600	3.050

TABLE X-2
SUMMARY OF TREATMENT EFFECTIVENESS
GALVANIZED SUBCATEGORY

PARAMETER	RAW WASTE		BPT (PSES 0)		BAT 1 (PSES 1)		BAT 2 (PSES 2)	
	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2
FLOW 1/m^2	2.610		2.610		0.896		0.896	
118 CADMIUM	0.045	0.117	0.045	0.117	0.079	0.071	0.049	0.044
119 CHROMIUM	57.600	150.336	0.080	0.209	0.080	0.072	0.070	0.063
120 COPPER	0.009	0.023	0.009	0.023	0.026	0.023	0.026	0.023
121 CYANIDE	0.082	0.214	0.070	0.183	0.070	0.063	0.047	0.042
122 LEAD	0.422	1.101	0.120	0.313	0.120	0.108	0.080	0.072
124 NICKEL	0.395	1.031	0.395	1.031	0.570	0.511	0.220	0.197
128 ZINC	25.489	66.526	0.300	0.783	0.300	0.269	0.230	0.206
TOXIC ORG.	0.118	0.308	0.022	0.057	0.022	0.020	0.022	0.020
IRON	2.829	7.384	0.410	1.070	0.410	0.367	0.280	0.251
PHOSPHORUS	14.758	38.518	4.080	10.649	4.080	3.656	2.720	2.437
OIL & GREASE	52.965	138.239	10.000	26.100	10.000	8.960	10.000	8.960
TSS	114.050	297.671	12.000	31.320	12.000	10.752	2.600	2.330

TABLE X-3
SUMMARY OF TREATMENT EFFECTIVENESS
ALUMINUM SUBCATEGORY

PARAMETER	RAW WASTE		BPT (PSES 0)		BAT 1 (PSES 1)		BAT 2 (PSES 2)	
	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2
FLOW 1/m^2	3.363		3.363		0.987		0.987	
118 CADMIUM	0.005	0.017	0.005	0.017	0.017	0.017	0.017	0.017
119 CHROMIUM	43.500	146.291	0.080	0.269	0.080	0.079	0.070	0.069
120 COPPER	0.043	0.145	0.043	0.145	0.147	0.145	0.147	0.145
121 CYANIDE	0.568	1.910	0.070	0.235	0.070	0.069	0.047	0.046
122 LEAD	0.118	0.397	0.118	0.397	0.120	0.118	0.080	0.079
124 NICKEL	0.003	0.010	0.003	0.010	0.010	0.010	0.010	0.010
128 ZINC	0.028	0.094	0.028	0.094	0.095	0.094	0.095	0.094
TOXIC ORG.	0.070	0.235	0.012	0.040	0.012	0.012	0.012	0.012
ALUMINUM	112.212	377.369	1.110	3.733	1.110	1.096	0.740	0.730
IRON	3.448	11.596	0.410	1.379	0.410	0.405	0.280	0.276
PHOSPHORUS	7.000	23.541	4.080	13.721	4.080	4.027	2.720	2.685
OIL & GREASE	57.561	193.578	10.000	33.630	10.000	9.870	10.000	9.870
TSS	84.884	285.465	12.000	40.356	12.000	11.844	2.600	2.566

TABLE X-4

SUMMARY OF RAW WASTEWATER ORGANICS

		STEEL		GALVANIZED		ALUMINUM	
		mg/1	mg/m^2	mg/1	mg/m^2	mg/1	mg/m^2
11	1,1,1-Trichloroethane	*	*	0.011	0.064	-	-
13	1,1-Dichloroethane	0.018	0.034	-	-	-	-
29	1,1-Dichloroethylene	-	-	0.015	0.016	-	-
30	1,2-Trans-Dichloroethylene	-	-	*	0.019	-	-
34	2,4-Dimethylphenol	0.021	0.032	-	-	-	-
39	Fluoranthene	0.040	0.036	*	*	*	*
54	Isophorone	0.600	0.909	*	*	-	-
55	Naphthalene	*	*	*	*	*	*
65	Phenol	0.016	0.024	0.00	0.00	0.00	0.00
66	Bis (2-ethylhexyl) phthalate	0.035	0.050	0.030	0.177	0.014	0.047
67	Butyl-benzyl phthalate	0.152	0.300	*	*	*	*
68	Di-n-butylphthalate	*	*	*	*	*	*
69	Di-n-octyl phthalate	0.027	0.031	*	*	*	*
70	Diethyl phthalate	0.056	0.158	0.048	0.174	0.056	0.188
71	Dimethyl phthalate	0.00	0.00	*	*	*	*
72	1,2-Benzanthracene	0.056	0.044	*	*	0.00	0.00
73	Benzo (a) pyrene	*	*	*	*	*	*
74	3,4-Benzofluoranthene	0.035	0.023	*	*	*	*
75	11,12-Benzofluoranthene	0.035	0.023	*	*	*	*
76	Chrysene	0.023	0.040	*	*	0.00	0.00
77	Acenaphthalene	*	*	*	*	0.00	0.00
78	Anthracene	0.064	0.097	*	*	*	*
79	1,12-Benzoperylene	0.00	0.00	0.00	0.00	*	*
80	Fluorene	0.028	0.100	0.005	0.016	*	*
81	Phenathrene	0.064	0.097	*	*	*	*
82	1,2,5,6-Dibenzanthracene	0.00	0.00	0.00	0.00	0.00	0.00
83	Indeno (1,2,3-cd)pyrene	0.00	0.00	0.00	0.00	0.00	0.00
84	Pyrene	0.012	0.024	*	*	0.00	0.00
86	Toluene	*	*	0.00	0.00	*	*
87	Trichloroethylene	*	*	*	*	-	-
	TOTAL	1.282	2.022	0.118	0.466	0.070	0.235

Blank indicates analysis not performed
- indicates not a verification parameter in respective category
* indicates parameter was detected but concentration was below a quantifiable level
0.0 indicates the parameter was not detected in all samples for which it was analyzed

TABLE X-5
POLLUTANT REDUCTION BENEFITS OF CONTROL SYSTEMS
STEEL SUBCATEGORY - NORMAL PLANT

PARAMETER	RAW WASTE kg/yr	BPT (PSES 0) Removed kg/yr	BPT (PSES 0) Discharged kg/yr	BAT 1 (PSES 1) Removed kg/yr	BAT 1 (PSES 1) Discharged kg/yr	BAT 2 (PSES 2) Removed kg/yr	BAT 2 (PSES 2) Discharged kg/yr
FLOW 1/yr (10^6)	33.55		33.55		14.30		14.30
118 CADMIUM	0.03	0.00	0.03	0.00	0.03	0.00	0.03
119 CHROMIUM	230.32	227.64	2.68	229.18	1.14	229.32	1.00
120 COPPER	1.71	0.00	1.71	0.00	1.71	0.00	1.71
121 CYANIDE	0.40	0.00	0.40	0.00	0.40	0.00	0.40
122 LEAD	4.76	0.73	4.03	3.04	1.72	3.62	1.14
124 NICKEL	13.15	0.00	13.15	5.00	8.15	10.00	3.15
128 ZINC	254.58	244.51	10.07	250.29	4.29	251.29	3.29
TOXIC ORG.	43.01	41.74	1.27	42.47	0.54	42.47	0.54
IRON	340.36	326.60	13.76	334.50	5.86	336.36	4.00
PHOSPHORUS	1438.42	1301.54	136.88	1380.08	58.34	1399.52	38.90
OIL & GREASE	11462.36	11126.86	335.50	11319.36	143.00	11319.36	143.00
TSS	5126.10	4723.50	402.60	4954.50	171.60	5088.92	37.18
TOXIC METALS	504.55	472.88	31.67	487.51	17.04	494.23	10.32
CONVENTIONALS	16588.46	15850.36	738.10	16273.86	314.60	16408.28	180.18
TOTAL TOXICS	547.96	514.62	33.34	529.98	17.98	536.70	11.26
TOTAL POLLU.	18915.20	17993.12	922.08	18518.42	396.78	18680.86	234.34
SLUDGE GEN		120232.79		124692.12		126072.93	

TABLE X-6
POLLUTANT REDUCTION BENEFITS OF CONTROL SYSTEMS
GALVANIZED SUBCATEGORY - NORMAL PLANT

PARAMETER	RAW WASTE	BPT (PSES 0)		BAT 1 (PSES 1)		BAT 2 (PSES 2)	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	30.02		30.02		10.30		10.30
118 CADMIUM	1.35	0.00	1.35	0.54	0.81	0.85	0.50
119 CHROMIUM	1729.15	1726.75	2.40	1728.33	0.82	1728.43	0.72
120 COPPER	0.27	0.00	0.27	0.00	0.27	0.00	0.27
121 CYANIDE	2.46	0.36	2.10	1.74	0.72	1.98	0.48
122 LEAD	12.67	9.07	3.60	11.43	1.24	11.85	0.82
124 NICKEL	11.86	0.00	11.86	5.99	5.87	9.59	2.27
128 ZINC	765.18	756.17	9.01	762.09	3.09	762.81	2.37
TOXIC ORG.	3.54	2.88	0.66	3.31	0.23	3.31	0.23
IRON	84.93	72.62	12.31	80.71	4.22	82.05	2.88
PHOSPHORUS	443.04	320.56	122.48	401.02	42.02	415.02	28.02
OIL & GREASE	1590.01	1289.81	300.20	1487.01	103.00	1487.01	103.00
TSS	3423.78	3063.54	360.24	3300.18	123.60	3397.00	26.78
TOXIC METALS	2520.48	2491.99	28.49	2508.38	12.10	2513.53	6.95
CONVENTIONALS	5013.79	4353.35	660.44	4787.19	226.60	4884.01	129.78
TOTAL TOXICS	2526.48	2495.23	31.25	2513.43	13.05	2518.82	7.66
TOTAL POLLU.	8068.24	7241.76	826.48	7782.35	285.89	7899.90	168.34
SLUDGE GEN		55892.55		60546.82		61552.60	

TABLE X-7
POLLUTANT REDUCTION BENEFITS OF CONTROL SYSTEMS
ALUMINUM SUBCATEGORY - NORMAL PLANT

PARAMETER	RAW WASTE	BPT (PSES 0)		BAT 1 (PSES 1)		BAT 2 (PSES 2)	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	97.80		97.80		28.70		28.70
118 CADMIUM	0.49	0.00	0.49	0.00	0.49	0.00	0.49
119 CHROMIUM	4254.30	4246.48	7.82	4252.00	2.30	4252.29	2.01
120 COPPER	4.21	0.00	4.21	0.00	4.21	0.00	4.21
121 CYANIDE	55.55	48.70	6.85	53.54	2.01	54.20	1.35
122 LEAD	11.54	0.00	11.54	8.10	3.44	9.24	2.30
124 NICKEL	0.29	0.00	0.29	0.00	0.29	0.00	0.29
128 ZINC	2.74	0.00	2.74	0.00	2.74	0.00	2.74
TOXIC ORG.	6.85	5.68	1.17	6.51	0.34	6.51	0.34
ALUMINUM	10974.33	10865.77	108.56	10942.47	31.86	10953.09	21.24
IRON	337.21	297.11	40.10	325.44	11.77	329.17	8.04
PHOSPHORUS	684.60	285.58	399.02	567.50	117.10	606.54	78.06
OIL & GREASE	5629.47	4651.47	978.00	5342.47	287.00	5342.47	287.00
TSS	8301.66	7128.06	1173.60	7957.26	344.40	8227.04	74.62
TOXIC METALS	4273.57	4246.48	27.09	4260.10	13.47	4261.53	12.04
CONVENTIONALS	13931.13	11779.53	2151.60	13299.73	631.40	13569.51	361.62
TOTAL TOXICS	4335.97	4300.86	35.11	4320.15	15.82	4322.24	13.73
TOTAL POLLU.	30263.24	27528.85	2734.39	29455.29	807.95	29780.55	482.69
SLUDGE GEN		423142.18		440651.42		443364.43	

TABLE X-8
TOTAL TREATMENT PERFORMANCE
STEEL SUBCATEGORY

PARAMETER	RAW WASTE	BPT & PSES 0		BAT 1 & PSES 1		BAT 2 & PSES 2	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	1341.88		1341.88		571.95		571.95
118 CADMIUM	1.34	0.00	1.34	0.00	1.34	0.00	1.34
119 CHROMIUM	9212.01	9104.66	107.35	9166.25	45.76	9171.97	40.04
120 COPPER	68.44	0.00	68.44	0.00	68.44	0.00	68.44
121 CYANIDE	16.10	0.00	16.10	0.00	16.10	0.00	16.10
122 LEAD	190.55	29.52	161.03	121.92	68.63	144.79	45.76
124 NICKEL	526.02	0.00	526.02	200.01	326.01	400.19	125.83
128 ZINC	10182.19	9779.63	402.56	10010.60	171.59	10050.64	131.55
TOXIC ORG.	1720.29	1669.30	50.99	1698.56	21.73	1698.56	21.73
IRON	13613.37	13063.20	550.17	13378.87	234.50	13453.22	160.15
PHOSPHORUS	57531.76	52056.89	5474.87	55198.20	2333.56	55976.06	1555.70
OIL & GREASE	458453.30	445034.50	13418.80	452733.80	5719.50	452733.80	5719.50
TSS	205025.85	188923.29	16102.56	198162.45	6863.40	203538.78	1487.07
TOXIC METALS	20180.55	18913.81	1266.74	19498.78	681.77	19767.59	412.96
CONVENTIONALS	663479.15	633957.79	29521.36	650896.25	12582.90	656272.58	7206.57
TOTAL TOXICS	21916.94	20583.11	1333.83	21197.34	719.60	21466.15	450.79
TOTAL POLLU.	756541.22	719660.99	36880.23	740670.66	15870.56	747168.01	9373.21
SLUDGE GEN		4808887.06		4987240.57		5042480.83	

TABLE X-9
TOTAL TREATMENT PERFORMANCE
GALVANIZED SUBCATEGORY

PARAMETER	RAW WASTE	BPT & PSES 0		BAT 1 & PSES 1		BAT 2 & PSES 2	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	600.30		600.30		206.08		206.08
118 CADMIUM	27.01	0.00	27.01	10.73	16.28	16.91	10.10
119 CHROMIUM	34577.28	34529.26	48.02	34560.79	16.49	34562.85	14.43
120 COPPER	5.40	0.00	5.40	0.00	5.40	0.00	5.40
121 CYANIDE	49.22	7.20	42.02	34.79	14.43	39.53	9.69
122 LEAD	253.33	181.29	72.04	228.60	24.73	236.84	16.49
124 NICKEL	237.12	0.00	237.12	119.65	117.47	191.78	45.34
128 ZINC	15301.05	15120.96	180.09	15239.23	61.82	15253.65	47.40
TOXIC ORG.	70.84	57.63	13.21	66.31	4.53	66.31	4.53
IRON	1698.25	1452.13	246.12	1613.76	84.49	1640.55	57.70
PHOSPHORUS	8859.23	6410.01	2449.22	8018.42	840.81	8298.69	560.54
OIL & GREASE	31794.89	25791.89	6003.00	29734.09	2060.80	29734.09	2060.80
TSS	68464.21	61260.61	7203.60	65991.25	2472.96	67928.40	535.81
TOXIC METALS	50401.19	49831.51	569.68	50159.00	242.19	50262.03	139.16
CONVENTIONALS	100259.10	87052.50	13206.60	95725.34	4533.76	97662.49	2596.61
TOTAL TOXICS	50521.25	49896.34	624.91	50260.10	261.15	50367.87	153.38
TOTAL POLLU.	161337.83	144810.98	16526.85	155617.62	5720.21	157969.60	3368.23
SLUDGE GEN		1117661.56		1210699.01		1230826.21	

TABLE X-10
TOTAL TREATMENT PERFORMANCE
ALUMINUM SUBCATEGORY

PARAMETER	RAW WASTE	BPT & PSES 0		BAT 1 & PSES 1		BAT 2 & PSES 2	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	4694.21		4694.21		1377.69		1377.69
118 CADMIUM	23.47	0.00	23.47	0.00	23.47	0.00	23.47
119 CHROMIUM	204198.13	203822.59	375.54	204087.91	110.22	204101.69	96.44
120 COPPER	201.85	0.00	201.85	0.00	201.85	0.00	201.85
121 CYANIDE	2666.31	2337.72	328.59	2569.87	96.44	2601.56	64.75
122 LEAD	553.92	0.00	553.92	388.60	165.32	443.70	110.22
124 NICKEL	14.08	0.00	14.08	0.00	14.08	0.00	14.08
128 ZINC	131.44	0.00	131.44	0.00	131.44	0.00	131.44
TOXIC ORG.	328.59	272.26	56.33	312.06	16.53	312.06	16.53
ALUMINUM	526746.69	521536.12	5210.57	525217.45	1529.24	525727.20	1019.49
IRON	16185.64	14261.01	1924.63	15620.79	564.85	15799.89	385.75
PHOSPHORUS	32859.47	13707.09	19152.38	27238.49	5620.98	29112.15	3747.32
OIL & GREASE	270203.42	223261.32	46942.10	256426.52	13776.90	256426.52	13776.90
TSS	398463.32	342132.80	56330.52	381931.04	16532.28	394881.33	3581.99
TOXIC METALS	205122.89	203822.59	1300.30	204476.51	646.38	204545.39	577.50
CONVENTIONALS	668666.74	565394.12	103272.62	638357.56	30309.18	651307.85	17358.89
TOTAL TOXICS	208117.79	206432.57	1685.22	207358.44	759.35	207459.01	658.78
TOTAL POLLU.	1452576.33	1321330.91	131245.42	1413792.73	38783.60	1429406.10	23170.23
SLUDGE GEN		20310010.20		21150390.73		21280616.61	

TABLE X-11
TREATMENT PERFORMANCE
TOTAL CATEGORY

PARAMETER	RAW WASTE	BPT & PSES 0		BAT 1 & PSES 1		BAT 2 & PSES 2	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	6636.39		6636.39		2155.72		2155.72
118 CADMIUM	51.82	0.00	51.82	10.73	41.09	16.91	34.91
119 CHROMIUM	247987.42	247456.51	530.91	247814.95	172.47	247836.51	150.91
120 COPPER	275.69	0.00	275.69	0.00	275.69	0.00	275.69
121 CYANIDE	2731.63	2344.92	386.71	2604.66	126.97	2641.09	90.54
122 LEAD	997.80	210.81	786.99	739.12	258.68	825.33	172.47
124 NICKEL	777.22	0.00	777.22	319.66	457.56	591.97	185.25
128 ZINC	25614.68	24900.59	714.09	25249.83	364.85	25304.29	310.39
TOXIC ORG.	2119.72	1999.19	120.53	2076.93	42.79	2076.93	42.79
ALUMINUM	526746.69	521536.12	5210.57	525217.45	1529.24	525727.20	1019.49
IRON	31497.26	28776.34	2720.92	30613.42	883.84	30893.66	603.60
PHOSPHORUS	99250.46	72173.99	27076.47	90455.11	8795.35	93386.90	5863.56
OIL & GREASE	760451.61	694087.71	66363.90	738894.41	21557.20	738894.41	21557.20
TSS	671953.38	592316.70	79636.68	646084.74	25868.64	666348.51	5604.87
TOXIC METALS	275704.63	272567.91	3136.72	274134.29	1570.34	274575.01	1129.62
CONVENTIONALS	1432404.99	1286404.41	146000.58	1384979.15	47425.84	1405242.92	27162.07
TOTAL TOXICS	280555.98	276912.02	3643.96	278815.88	1740.10	279293.03	1262.95
TOTAL POLLU.	2370455.38	2185802.88	184652.50	2310081.01	60374.37	2334543.71	35911.67
SLUDGE GEN		26236558.82		27348330.31		27553923.65	

TABLE X-12
SUMMARY TABLE
POLLUTANT REDUCTION BENEFITS
TOTAL CATEGORY

	RAW WASTE	BPT		BAT 1		BAT 2	
		Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
Steel Subcategory							
TOXIC METALS	20180.55	18913.81	1266.74	19498.78	681.77	19767.59	412.96
CONVENTIONALS	663479.15	633957.79	29521.36	650896.25	12582.90	656272.58	7206.57
TOTAL TOXICS	21916.94	20583.11	1333.83	21197.34	719.60	21466.15	450.79
TOTAL POLLU.	756541.22	719660.99	36880.23	740670.66	15870.56	747168.01	9373.21
Galvanized Subcategory							
TOXIC METALS	50401.19	49831.51	569.68	50159.00	242.19	50262.03	139.16
CONVENTIONALS	100259.10	87052.50	13206.60	95725.34	4533.76	97662.49	2596.61
TOTAL TOXICS	50521.25	49896.34	624.91	50260.10	261.15	50367.87	153.38
TOTAL POLLU.	161337.83	144810.98	16526.85	155617.62	5720.21	157969.60	3368.23
Aluminum Subcategory							
TOXIC METALS	205122.89	203822.59	1300.30	204476.51	646.38	204545.39	577.50
CONVENTIONALS	668666.74	565394.12	103272.62	638357.56	30309.18	651307.85	17358.89
TOTAL TOXICS	208117.79	206432.57	1685.22	207358.44	759.35	207459.01	658.78
TOTAL POLLU.	1452576.33	1321330.91	131245.42	1413792.73	38783.60	1429406.10	23170.23
Total Subcategory							
TOXIC METALS	275704.63	272567.91	3136.72	274134.29	1570.34	274575.01	1129.62
CONVENTIONALS	1432404.99	1286404.41	146000.58	1384979.15	47425.84	1405242.92	27162.07
TOTAL TOXICS	280555.98	276912.02	3643.96	278815.88	1740.10	279293.03	1262.95
TOTAL POLLU.	2370455.38	2185802.88	184652.50	2310081.01	60374.37	2334543.71	35911.67

TABLE X-13
TREATMENT PERFORMANCE - DIRECT DISCHARGERS
STEEL SUBCATEGORY

PARAMETER	RAW WASTE	BPT		BAT 1		BAT 2	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	436.11		436.11		185.88		185.88
118 CADMIUM	0.43	0.00	0.43	0.00	0.43	0.00	0.43
119 CHROMIUM	2993.90	2959.01	34.89	2979.03	14.87	2980.88	13.02
120 COPPER	22.25	0.00	22.25	0.00	22.25	0.00	22.25
121 CYANIDE	5.23	0.00	5.23	0.00	5.23	0.00	5.23
122 LEAD	61.93	9.59	52.34	39.63	22.30	47.06	14.87
124 NICKEL	170.96	0.00	170.96	65.01	105.95	130.07	40.89
128 ZINC	3309.21	3178.38	130.83	3253.44	55.77	3266.46	42.75
TOXIC ORG.	559.09	542.52	16.57	552.03	7.06	552.03	7.06
IRON	4424.33	4245.53	178.80	4348.12	76.21	4372.28	52.05
PHOSPHORUS	18697.78	16918.45	1779.33	17939.39	758.39	18192.19	505.59
OIL & GREASE	148996.98	144635.88	4361.10	147138.18	1858.80	147138.18	1858.80
TSS	66633.25	61399.93	5233.32	64402.69	2230.56	66149.96	483.29
TOXIC METALS	6558.68	6146.98	411.70	6337.11	221.57	6424.47	134.21
CONVENTIONALS	215630.23	206035.81	9594.42	211540.87	4089.36	213288.14	2342.09
TOTAL TOXICS	7123.00	6689.50	433.50	6889.14	233.86	6976.50	146.50
TOTAL POLLU.	245875.34	233889.29	11986.05	240717.52	5157.82	242829.11	3046.23
SLUDGE GEN		1562884.74		1620850.62		1638803.35	

TABLE X-14
TREATMENT PERFORMANCE - DIRECT DISCHARGERS
GALVANIZED SUBCATEGORY

PARAMETER	RAW WASTE	BPT		BAT 1		BAT 2	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	90.04		90.04		30.91		30.91
118 CADMIUM	4.05	0.00	4.05	1.61	2.44	2.53	1.52
119 CHROMIUM	5186.30	5179.10	7.20	5183.82	2.48	5184.13	2.17
120 COPPER	0.81	0.00	0.81	0.00	0.81	0.00	0.81
121 CYANIDE	7.38	1.08	6.30	5.21	2.17	5.92	1.46
122 LEAD	38.00	27.19	10.81	34.29	3.71	35.52	2.48
124 NICKEL	35.57	0.00	35.57	17.95	17.62	28.77	6.80
128 ZINC	2295.03	2268.02	27.01	2285.76	9.27	2287.92	7.11
TOXIC ORG.	10.63	8.65	1.98	9.95	0.68	9.95	0.68
IRON	254.72	217.81	36.91	242.05	12.67	246.07	8.65
PHOSPHORUS	1328.81	961.45	367.36	1202.69	126.12	1244.73	84.08
OIL & GREASE	4768.97	3868.57	900.40	4459.87	309.10	4459.87	309.10
TSS	10269.06	9188.58	1080.48	9898.14	370.92	10188.69	80.37
TOXIC METALS	7559.76	7474.31	85.45	7523.43	36.33	7538.87	20.89
CONVENTIONALS	15038.03	13057.15	1980.88	14358.01	680.02	14648.56	389.47
TOTAL TOXICS	7577.77	7484.04	93.73	7538.59	39.18	7554.74	23.03
TOTAL POLLU.	24199.33	21720.45	2478.88	23341.34	857.99	23694.10	505.23
SLUDGE GEN		167640.01		181594.40		184613.22	

TABLE X-15
TREATMENT PERFORMANCE - DIRECT DISCHARGERS
ALUMINUM SUBCATEGORY

PARAMETER	RAW WASTE	BPT		BAT 1		BAT 2	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	2249.31		2249.31		660.14		660.14
118 CADMIUM	11.25	0.00	11.25	0.00	11.25	0.00	11.25
119 CHROMIUM	97844.98	97665.03	179.95	97792.16	52.82	97798.77	46.21
120 COPPER	96.72	0.00	96.72	0.00	96.72	0.00	96.72
121 CYANIDE	1277.61	1120.16	157.45	1231.40	46.21	1246.58	31.03
122 LEAD	265.42	0.00	265.42	186.21	79.21	212.60	52.82
124 NICKEL	6.75	0.00	6.75	0.00	6.75	0.00	6.75
128 ZINC	62.98	0.00	62.98	0.00	62.98	0.00	62.98
TOXIC ORG.	157.45	130.46	26.99	149.53	7.92	149.53	7.92
ALUMINUM	252399.57	249902.84	2496.73	251666.81	732.76	251911.07	488.50
IRON	7755.62	6833.40	922.22	7484.97	270.65	7570.78	184.84
PHOSPHORUS	15745.17	6567.98	9177.19	13051.79	2693.38	13949.59	1795.58
OIL & GREASE	129472.53	106979.43	22493.10	122871.13	6601.40	122871.13	6601.40
TSS	190930.43	163938.71	26991.72	183008.75	7921.68	189214.07	1716.36
TOXIC METALS	98288.10	97665.03	623.07	97978.37	309.73	98011.37	276.73
CONVENTIONALS	320402.96	270918.14	49484.82	305879.88	14523.08	312085.20	8317.76
TOTAL TOXICS	99723.16	98915.65	807.51	99359.30	363.86	99407.48	315.68
TOTAL POLLU.	696026.48	633138.01	62888.47	677442.75	18583.73	684924.12	11102.36
SLUDGE GEN		9731884.28		10134567.60		10196967.27	

TABLE X-16
TREATMENT PERFORMANCE
TOTAL CATEGORY - DIRECT DISCHARGERS

PARAMETER	RAW WASTE	BPT		BAT 1		BAT 2	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	2775.46		2775.46		876.93		876.93
118 CADMIUM	15.73	0.00	15.73	1.61	14.12	2.53	13.20
119 CHROMIUM	106025.18	105803.14	222.04	105955.01	70.17	105963.78	61.40
120 COPPER	119.78	0.00	119.78	0.00	119.78	0.00	119.78
121 CYANIDE	1290.22	1121.24	168.98	1236.61	53.61	1252.50	37.72
122 LEAD	365.35	36.78	328.57	260.13	105.22	295.18	70.17
124 NICKEL	213.28	0.00	213.28	82.96	130.32	158.84	54.44
128 ZINC	5667.22	5446.40	220.82	5539.20	128.02	5554.38	112.84
TOXIC ORG.	727.17	681.63	45.54	711.51	15.66	711.51	15.66
ALUMINUM	252399.57	249902.84	2496.73	251666.81	732.76	251911.07	488.50
IRON	12434.67	11296.74	1137.93	12075.14	359.53	12189.13	245.54
PHOSPHORUS	35771.76	24447.88	11323.88	32193.87	3577.89	33386.51	2385.25
OIL & GREASE	283238.48	255483.88	27754.60	274469.18	8769.30	274469.18	8769.30
TSS	267832.74	234527.22	33305.52	257309.58	10523.16	265552.72	2280.02
TOXIC METALS	112406.54	111286.32	1120.22	111838.91	567.63	111974.71	431.83
CONVENTIONALS	551071.22	490011.10	61060.12	531778.76	19292.46	540021.90	11049.32
TOTAL TOXICS	114423.93	113089.19	1334.74	113787.03	636.90	113938.72	485.21
TOTAL POLLU.	966101.15	888747.75	77353.40	941501.61	24599.54	951447.33	14653.82
SLUDGE GEN		11462409.03		11937012.62		12020383.84	

TABLE X-17
SUMMARY TABLE
POLLUTANT REDUCTION BENEFITS
DIRECT DISCHARGERS

	RAW WASTE	BPT		BAT 1		BAT 2	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
Steel Subcategory							
TOXIC METALS	6558.68	6146.98	411.70	6337.11	221.57	6424.47	134.21
CONVENTIONALS	215630.23	206035.81	9594.42	211540.87	4089.36	213288.14	2342.09
TOTAL TOXICS	7123.00	6689.50	433.50	6889.14	233.86	6976.50	146.50
TOTAL POLLU.	245875.34	233889.29	11986.05	240717.52	5157.82	242829.11	3046.23
Galvanized Subcategory							
TOXIC METALS	7559.76	7474.31	85.45	7523.43	36.33	7538.87	20.89
CONVENTIONALS	15038.03	13057.15	1980.88	14358.01	680.02	14648.56	389.47
TOTAL TOXICS	7577.77	7484.04	93.73	7538.59	39.18	7554.74	23.03
TOTAL POLLU.	24199.33	21720.45	2478.88	23341.34	857.99	23694.10	505.23
Aluminum Subcategory							
TOXIC METALS	98288.10	97665.03	623.07	97978.37	309.73	98011.37	276.73
CONVENTIONALS	320402.96	270918.14	49484.82	305879.88	14523.08	312085.20	8317.76
TOTAL TOXICS	99723.16	98915.65	807.51	99359.30	363.86	99407.48	315.68
TOTAL POLLU.	696026.48	633138.01	62888.47	677442.75	18583.73	684924.12	11102.36
Total Subcategory							
TOXIC METALS	112406.54	111286.32	1120.22	111838.91	567.63	111974.71	431.83
CONVENTIONALS	551071.22	490011.10	61060.12	531778.76	19292.46	540021.90	11049.32
TOTAL TOXICS	114423.93	113089.19	1334.74	113787.03	636.90	113938.72	485.21
TOTAL POLLU.	966101.15	888747.75	77353.40	941501.61	24599.54	951447.33	14653.82

TABLE X-18

TREATMENT COSTS

	Capital In Place	BPT (PSES 0) Capital Costs $	BPT (PSES 0) Annual Costs $	BAT 1 (PSES 1) Capital Costs $	BAT 1 (PSES 1) Annual Costs $	BAT 2 (PSES 2) Capital Costs $	BAT 2 (PSES 2) Annual Costs $
Steel Subcategory							
Normal Plant	39000	157000	55000	154000	54000	182000	84000
Direct Dischargers	504000	2321000	858000	2267000	854000	2800000	1287000
Indirect Dischargers	1047000	3946000	1329000	3875000	1318000	4493000	2062000
Subcategory Total	1551000	6267000	2187000	6142000	2172000	7293000	3349000
Galvanized Subcategory							
Normal Plant	145000	102000	34000	92000	33000	111000	51000
Direct Dischargers	436000	231000	86000	208000	82000	273000	125000
Indirect Dischargers	2470000	1811000	593000	1624000	584000	1941000	892000
Subcategory Total	2906000	2042000	679000	1832000	666000	2214000	1017000
Aluminum Subcategory							
Normal Plant	83000	194000	67000	192000	66000	233000	104000
Direct Dischargers	1911000	4429000	1722000	4436000	1707000	5314000	2484000
Indirect Dischargers	2078000	4878000	1499000	4787000	1482000	5857000	2509000
Subcategory Total	3989000	9307000	3221000	9223000	3189000	11171000	4993000
Category							
Direct Dischargers	2851000	6981000	2721000	6911000	2643000	8387000	3896000
Indirect Dischargers	5595000	10635000	3421000	10286000	3384000	12291000	5463000
Category Total	8446000	17616000	6087000	17197000	6027000	20678000	9359000

NOTE: Capital costs are presented as incremental costs above "Capital In Place."
Annual costs include continuing operation of "Capital In Place."

TABLE X-19
BAT EFFLUENT LIMITATIONS
STEEL SUBCATEGORY

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2	$(lb/1,000,000\ ft^2)$	mg/m^2	$(lb/1,000,000\ ft^2)$
CADMIUM	0.375	(0.077)	0.176	(0.036)
*CHROMIUM	0.493	(0.101)	0.199	(0.041)
COPPER	2.229	(0.457)	1.173	(0.240)
*CYANIDE	0.340	(0.070)	0.141	(0.029)
LEAD	0.176	(0.036)	0.152	(0.031)
NICKEL	1.654	(0.339)	1.173	(0.240)
*ZINC	1.560	(0.320)	0.657	(0.135)
*IRON	1.443	(0.296)	0.739	(0.151)

TABLE X-20
BAT EFFLUENT LIMITATIONS
GALVANIZED SUBCATEGORY

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2	$(lb/1,000,000\ ft^2)$	mg/m^2	$(lb/1,000,000\ ft^2)$
CADMIUM	0.287	(0.059)	0.134	(0.027)
*CHROMIUM	0.376	(0.077)	0.152	(0.031)
*COPPER	1.702	(0.349)	0.896	(0.184)
*CYANIDE	0.260	(0.053)	0.108	(0.022)
LEAD	0.134	(0.027)	0.116	(0.024)
NICKEL	1.263	(0.259)	0.896	(0.184)
*ZINC	1.192	(0.244)	0.502	(0.103)
*IRON	1.102	(0.226)	0.564	(0.116)

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE X-21
BAT EFFLUENT LIMITATIONS
ALUMINUM SUBCATEGORY

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2	$(lb/1,000,000\ ft^2)$	mg/m^2	$(lb/1,000,000\ ft^2)$
CADMIUM	0.316	(0.065)	0.148	(0.030)
*CHROMIUM	0.415	(0.085)	0.168	(0.034)
COPPER	1.875	(0.384)	0.987	(0.202)
*CYANIDE	0.286	(0.059)	0.118	(0.024)
LEAD	0.148	(0.030)	0.128	(0.026)
NICKEL	1.392	(0.285)	0.987	(0.202)
*ZINC	1.313	(0.269)	0.553	(0.113)
*ALUMINUM	4.491	(0.920)	1.836	(0.376)
IRON	1.214	(0.249)	0.622	(0.127)

* THIS POLLUTANT IS REGULATED AT PROMULGATION

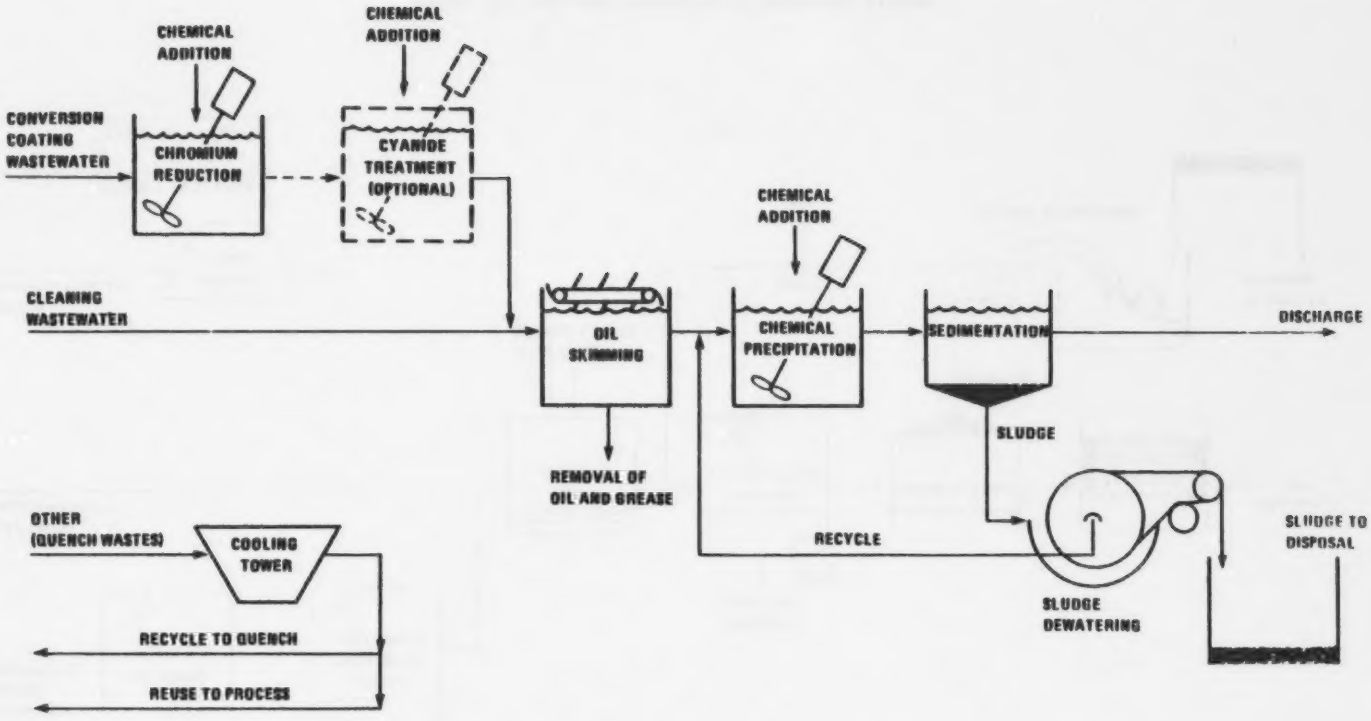

CHEMICAL ADDITION
CHEMICAL ADDITION
CONVERSION COATING WASTEWATER
CHROMIUM REDUCTION
CYANIDE TREATMENT (OPTIONAL)
CHEMICAL ADDITION
CLEANING WASTEWATER
OIL SKIMMING
CHEMICAL PRECIPITATION
SEDIMENTATION
DISCHARGE
SLUDGE
REMOVAL OF OIL AND GREASE
RECYCLE
SLUDGE TO DISPOSAL
SLUDGE DEWATERING
OTHER (QUENCH WASTES)
COOLING TOWER
RECYCLE TO QUENCH
REUSE TO PROCESS

FIGURE X-1. BAT LEVEL 1 WASTEWATER TREATMENT SYSTEM

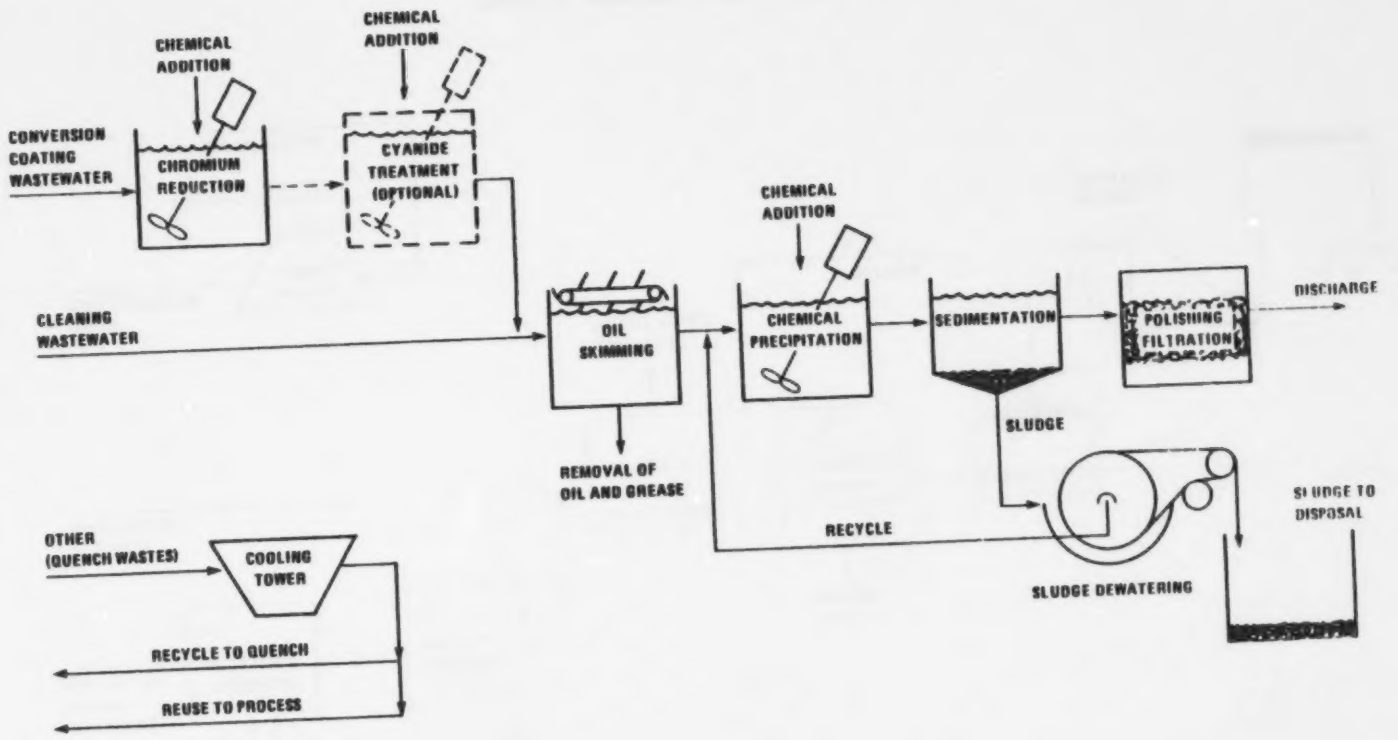

CONVERSION COATING WASTEWATER
CHEMICAL ADDITION
CHROMIUM REDUCTION
CHEMICAL ADDITION
CYANIDE TREATMENT (OPTIONAL)
CLEANING WASTEWATER
OIL SKIMMING
REMOVAL OF OIL AND GREASE
CHEMICAL ADDITION
CHEMICAL PRECIPITATION
SEDIMENTATION
POLISHING FILTRATION
DISCHARGE
SLUDGE
RECYCLE
SLUDGE DEWATERING
SLUDGE TO DISPOSAL
OTHER (QUENCH WASTES)
COOLING TOWER
RECYCLE TO QUENCH
REUSE TO PROCESS

FIGURE X-2. BAT LEVEL 2 WASTEWATER TREATMENT SYSTEM

SECTION XI
NEW SOURCE PERFORMANCE STANDARDS

This section presents effluent characteristics attainable by new sources through the application of the best available demonstrated control technology (BDT), processes, operating methods, or other alternatives, including where practicable, a standard permitting no discharge of pollutants. Possible model NSPS technologies are discussed with respect to costs, performance, and effluent reduction benefits. The rationale for selecting one of the technologies is outlined. The selection of pollutant parameters for specific regulation is discussed, and discharge limitations for the regulated pollutants are presented for each subcategory.

TECHNICAL APPROACH TO NSPS

As a general approach for the category, three levels of NSPS were evaluated. The technologies are equally applicable to all subcategories and each level can produce similar concentrations of pollutants in the effluent from all three subcategories. Mass limitations will vary among subcategories because of differences in water use.

The Agency proposed NSPS based on:

- in-process wastewater reduction
    - countercurrent cascade rinses (cleaning)
    - quench water recycle through cooling tower
    - quench water reuse as cleaning rinse
    - rinse sensors to shut off unused flow
- in-process pollutant reduction
    - non-cyanide conversion coating
    - no-rinse conversion coating
- oil skimming
- hydroxide precipitation of metals, sedimentation and filtration

- sludge dewatering

Additionally, treatment options considered before proposal included the application of ultrafiltration in place of conventional filtration and the application of membrane filtration in place of sedimentation.

Industry commented that the use of no rinse conversion coating was not generally applicable because there are no Food and Drug Administration approved no rinse conversion coatings. In light of these comments, the Agency reexamined the requirement that no wastewater be discharged from conversion coating processes as described at proposal.

The final NSPS allows 20 percent blowdown from quenching operations to be used after conversion coating as well as after cleaning. This is adequate flow allowance to permit conventional conversion coating if three stage countercurrent cascade rinsing is employed for cleaning and conversion coating rinse water. Hexavalent chromium reduction has been included in the NSPS model technology since no rinse conversion coating, which would eliminate the discharge of chromium, has been deleted.

Some industry sources stated that cyanide is not used in cleaner formulations and is a conversion coating process chemical only in the aluminum subcategory and that a severe product quality penalty could result from total application of non-cyanide processing. The final regulation allows some discharge of cyanide. The Agency stated at proposal that the preferred mechanism for control of cyanide is the use of non-cyanide conversion coating. To encourage this change, a plant may be exempted from the requirement of monitoring cyanide if it demonstrates and certifies that it neither has nor uses cyanide in its processes and it will not initiate such use.

The model technology basis for NSPS is: recycle of quench water, reuse of quench water blowdown as cleaning and conversion coating rinse water, three stage countercurrent cascade rinsing for both cleaning and conversion coating, removal of cyanide and reduction of hexavalent chromium from conversion coating rinses, oil skimming, precipitation of metals, sedimentation, polishing filtration, and dewatering of sludge.

The methods for water use reduction included in the NSPS model technology are described below:

Countercurrent Rinses - Countercurrent rinsing is a mechanism commonly encountered in electroplating and other metal processing operations where uncontaminated water is used for the final cleaning of an item, and water containing progressively more contamination is used to rinse the more contaminated part. The process achieves substantial efficiencies of water use and rinsing; for example, the use of a two stage countercurrent rinse to obtain a rinse ratio of about 100 can reduce water usage by a factor of approximately 10 from that needed for a single stage rinse to achieve the same level of product cleanliness. Similarly, a three stage countercurrent rinse would reduce water usage approximately 30 times for the same rinse ratio. Countercurrent rinsing is presently used in one coil coating plant.

Quench Water Recycle - The cooling and recycle of quench water is commonly practiced throughout the industry and 20 plants are believed to use cooling towers and recycle some substantial fraction of their cooling or quench water. Because the principle function of quench water is to remove heat quickly from the painted coil, the principle requirements of the water are that it be cool and that it not contain dissolved solids at such level that it leaves water marks or other discolorations on the painted surface. There is sufficient industry experience to assure the success of this technology; six plants already do not discharge any quench water by reason of continued recycle.

Quench Water Reuse - Water that has been used one or two cycles as quench water appears to be satisfactory for further use as rinse water in the coil coating operation. The amount of water used for quench purposes is about 1.5 times the once through amount of rinse water used in a coil coating plant, so that some level of recirculation would be required to completely use the quench water. This does not appear to be unreasonable; three plants are presently using part or all of their quench water blowdown for other coil coating purposes.

Rinse Sensors - Sensing devices that shut off rinse water when the coil coating line is not running eliminate unnecessary water flow. These devices have been observed installed and operating at six of the coil coating plants visited.

For the final NSPS, EPA considered making NSPS equivalent to the final BAT which consists of recycle of quench water using cooling towers, use of blowdown from cooling towers to provide rinse water, removal of cyanide and reduction of hexavalent chromium from conversion coating rinses, combination of rinse waters and treatment with lime, settling of suspended solids, skimming of oil from settling unit, and dewatering of sludge (Figure X-1, page 429).

EPA selected the final NSPS because it provides a reduced discharge of all pollutants below the final BAT (see Tables XI-2, 3 and 4). The model NSPS technology is less costly than the BAT technology because the flow reduction achieved will allow the use of a smaller treatment system (see Table XI-1).

Cost and Effluent Reduction Benefits of NSPS

Estimates of capital and annual costs for NSPS for each subcategory are presented in Table XI-1 (page 439) which is based on January 1978 dollars.

In calculating NSPS costs, EPA Used the "normal Plant" production as derived in Section X. The average production for the steel, galvanized and aluminum subcategories are 12.19, 11.50 and 29.08 sq meters [million] per year, respectively. An average plant production was multiplied by a production normalized flow for each subcategory. Control technology was sized for the normal plant.

The pollutant reduction benefit for each subcategory was derived by (a) characterizing raw wastewater and effluent from each proposed treatment system in terms of concentrations produced and production normalized discharges for each significant pollutant found in each subcategory; and (b) calculating the quantities removed and discharged in one year by a "normal plant." Results of these calculations were presented in Tables X-5, X-6, and X-7. Comparison of Table XI-1 with Tables X-5, X-6, and X-7 shows that BDT-1 costs less and produces greater incremental benefits than the other BDT options. All pollutant parameter calculations were based on median total raw wastewater concentrations for visited plants. See Table V-31 (Page 103).

REGULATED POLLUTANT PARAMETERS

The Agency reviewed the wastewater concentrations from individual operations and from the subcategory total to select those pollutant parameters found most frequently and at the highest levels. In Section VI each of the toxic pollutants was evaluated and a determination was made as to whether or not to further consider them for regulation. Pollutants were not considered for regulation if they were not detected, detected at nonquantifiable levels, unique to a small number of plants, or not treatable using technologies considered. All toxic pollutants listed for further consideration are discussed in this section.

In each subcategory oil and grease, TSS, and pH were selected for regulation with several toxic or non-conventional metal pollutants plus cyanide. In the propsoed regulation, the toxic metals selected for control included all those for which the concentration in the raw wastewater was above the treatability limit. EPA decided to regulate three or four metals in each subcategory and to use the parameter pH as an indicator to ensure control of the unregulated toxic metals. Maintaining effluent pH within optimum pH levels assures removal of those toxic metals not selected for specific regulation.

Chromate conversion coating can be applied to aluminum and galvanized surfaces and cyanide compounds are used in some conversion coating formulations applied to aluminum strip. To insure that there is no additional discharge of pollutants from conversion coating waters, chromium is regulated in the aluminum and galvanized subcategories for the steel subcategory, chromium is also regulated because of discharges from cleaning operations. Cyanide is regulated in all subcategories, but if a plant demonstrates and certifies that it neither has nor uses cyanide, it may be exempt from the requirement of monitoring cyanide.

In addition to the pollutant parameters listed above, there is a amount of other toxic pollutants in the coil coating wastewaters. The Agency is using an oil and grease standard for new sources in order to control the polynuclear aromatic hydrocarbons and oil soluble organics found in these wastewaters. Although a specific numeric standard for organic priority pollutants is not established, adequate control is expected to be achieved by control of the oil and grease wastes. This is projected to occur because of the slight solubility of the compounds in water and their relatively high solubility in oil. This difference in solubility will cause the organics to accumulate in and be removed with the oil (See Table VII-11, page 264).

The metals selected for specific regulation are discussed by subcategory. The performance standards achieved by application of BDT also are presented by subcategory. Hexavalent chromium is not regulated specifically because it is included in total chromium. Only the trivalent form is removed by the lime-settle-filter technology. Therefore, the hexavalent form must be reduced to meet the limitation on total chromium in each subcategory.

STEEL SUBCATEGORY

Applying the NSPS technology, the quench water would be recycled and the blowdown of 20 percent of quench flow would be used for countercurrent cascade rinsing. The NSPS wastewater flow for the steel subcategory was obtained using visited plant data model to determine what portion of total plant flow (all operations) is attributable to 20 percent of quench. A ratio was calculated using the model (visited plant data) by dividing 20 percent of the mean flow for all operations. This ratio was then applied to mean flow for all operations as calculated from the dcp responses to determine the NSPS. The dcp responses provide an extensive data base.

The visited plant mean water use for quench operations in the category as set forth in Section V is 3.632 l/sq m processed area. The visited plant mean water use for all operations in the steel subcategory l/sq m and the dcp responses mean water use for all operations is 2.752 l/sq m. The wastewater allowance for the subcategory would then become 0.316 l/sq m which is 91 percent of the proposed wastewater allowance. This flow will be used to calculate expected performance for new direct dischargers in the steel subcategory.

Pollutant parameters selected for regulation in the steel subcategory for NSPS are: chromium, cyanide, zinc, iron, oil and grease, TSS, and pH. The end-of-pipe treatment applied to the reduced flow would produce effluent concentrations of regulated pollutants equal to those shown in Section VII, Table VII-19 , for precipitation, sedimentation, and filtration (lime, settle, and filter) technology. pH must be maintained within the range of 7.5 - 10.0 at all times.

When these concentrations are applied to the water flows described above, the mass of pollutant allowed to be discharged per unit area of steel coil cleaned and conversion coated can be calculated. Table XI-5 shows the performance standards derived from this calculation.

GALVANIZED SUBCATEGORY

Applying the NSPS model technology, the quench water would be recycled and the blowdown of 20 percent of quench flow would be used for countercurrent cascade rinsing. The NSPS wastewater flow for the galvanized subcategory was obtained using visited plant data as a model to determine what portion of total plant flow (all operations) is attributable to 20 percent of quench. A ratio was calculated using the model (visited plant data) by dividing 20 percent of the mean flow for quench by the mean flow for all operations. This ratio was then applied to mean flow for all operations as calculated from the dcp responses to determine the NSPS flow. The dcp responses provide a more extensive data base. The visited plant mean water use for quench oeprations in the category as set forth in Section V is 3.632 l/sq m processed area. The visited plant mean water use for all operations in the galvanized subcategory is 5.53 l/sq m and the dcp response mean water use for all operations is 2.610 l/sq m. The wastewater allowance for the subcategory would then become 0.343 l/sq m which is 80 percent of the proposed wastewater allowance. This flow will be used to calculate expected performance for new direct dischargers in the galvanized subcategory.

Pollutant parameters selected for regulation in the galvanized subcategory for BDT are: chromium, copper, cyanide, zinc, iron, oil and grease, TSS and pH. The end-of-pipe treatment applied to reduced flow would produce effluent conçentrations of regulated pollutants equal to those shown in Section VII, Table VII-19 precipitation, sedimentation, and filtration (lime-settle-filter) technology. pH must be maintained within the range 7.5 - 10-0 at all times.

When these concentrations are applied to the water flows described above, the mass of pollutant allowed to be discharged per unit area galvanized coil cleaned and conversion coated can be calculated. Table XI-6 shows the standards derived from this calculation.

ALUMINUM SUBCATEGORY

Applying the NSPS technology, the quench water would be recycled and the blowdown of 20 percent of quench flow would be used for countercurrent cascade rinsing. The NSPS qastewater flow for the aluminum subcategory was obtained using visited plant data as a model to determine what portion of total plant flow (all operations) is attributable to 20 percent of quench. A ratio was calculated using the model (visited plant data) by dividing 20 percent of the mean flow for quench by the mean flow for all operations. This ratio was then applied to mean flow for all operations as calculated from the dcp responses to determine the NSPS flow. The dcp responses provide a more extensive data base.

The visited plant mean water use for quench operations in the category as set forth in Section V is 3.632 l/sq m processed area. The visited plant mean water use for all operations is 5.14 l/sq m and the dcp response mean water use for all operations is 3.363 l/sq m. the wastewater allowance for the subcategory would then become 0.475 l/sq m which is 126 percent of the proposed wastewater allowance. This flow will be used to calculate expected performance for new direct dischargers in the aluminum subcategory.

Pollutant parameters selected for regulation in the aluminum subcategory for NSPS are: chromium, cyanide, zinc, aluminum, oil and grease, TSS, and pH. The end-of-pipe treatment applied to reduced flow would produce effluent concentrations of regulated pollutants equal to those shown in Section VII, Table VII-19 for precipitation, sedimentation, and filtration (lime-settle-filter) technology. pH must be maintained within the range 7.5 - 10.0 at all times.

When these concentrations are applied to the water flows described above, the mass of pollutant allowed to be discharged per unit area of aluminum coil cleaned and conversion coated can be calculated. Table XI-7 shows the standards derived from this calculation.

DEMONSTRATION STATUS

No sampled coil The NSPS model system has all the same treatment components as BAT plus countercurrent rinse and polishing filters. coating plant in any subcategory uses all of the NSPS technology. However, each major element of the NSPS technology is demonstrated in one or more coil coating plants except for polishing filters. Countercurrent rinse is demonstrated at 2 coil coating plants. Polishing filters, while not in use at coil coating plants, are widely known to be effective in reducing TSS and precipitated metals (See Section VII) in categories whose wastewaters are similar to coil coating wastewater.

TABLE XI-1

COSTS OF BDT FOR COIL COATING NSPS
NORMAL PLANT

	Final NSPS (PSNS)		Final BAT (PSES)	
	Capital Costs $	Annual Costs $	Capital Costs $	Annual Costs $
Steel Subcategory				
Normal Plant	171,500	51,300	305,000	77,400
Flow, liters/year	$3.9x10^6$		$14.3x10^6$	
Production, sq m/year	$12.19x10^6$		$12.19x10^6$	
Galvanized Subcategory				
Normal Plant	172,500	51,800	288,100	72,300
Flow, liters/year	$3.9x10^6$		$10.3x10^6$	
Production, sq m/year	$11.50x10^6$		$11.50x10^6$	
Aluminum Subcategory				
Normal Plant	316,800	89,600	355,700	103,200
Flow, liters/year	$13.8x10^6$		$28.7x10^6$	
Production, sq m/year	$29.08x10^6$		$29.08x10^6$	

TABLE XI-2
POLLUTANT REDUCTION BENEFITS OF CONTROL SYSTEMS
STEEL SUBCATEGORY - NORMAL PLANT

PARAMETER	RAW WASTE	Final NSPS (PSNS)		Final BAT (PSES)	
		Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
FLOW 1/yr (10^6)	33.55		3.85		14.30
118 CADMIUM	0.03	0.00	0.03	0.00	0.03
119 CHROMIUM	230.32	230.05	0.27	229.18	1.14
120 COPPER	1.71	0.21	1.50	0.00	1.71
121 CYANIDE	0.40	0.22	0.18	0.00	0.40
122 LEAD	4.76	4.45	0.31	3.04	1.72
124 NICKEL	13.15	12.30	0.85	5.00	8.15
128 ZINC	254.58	253.69	0.89	250.29	4.29
TOXIC ORG.	43.01	42.86	0.15	42.47	0.54
IRON	340.36	339.28	1.08	334.50	5.86
PHOSPHORUS	1438.42	1427.95	10.47	1380.08	58.34
OIL & GREASE	11462.36	11423.86	38.50	11319.36	143.00
TSS	5126.10	5116.09	10.01	4954.50	171.60
TOXIC METALS	504.55	500.70	3.85	487.51	17.04
CONVENTIONALS	16588.46	16539.95	48.51	16273.86	314.60
TOTAL TOXICS	547.96	543.78	4.18	529.98	17.98
TOTAL POLLU.	18915.20	18850.96	64.24	18518.42	396.78
SLUDGE GEN		127612.57		124692.12	

TABLE XI-3
POLLUTANT REDUCTION BENEFITS OF CONTROL SYSTEMS
GALVANIZED SUBCATEGORY - NORMAL PLANT

PARAMETER	RAW WASTE	Final NSPS (PSNS)		Final BAT (PSES)	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	30.02		3.94		10.30
118 CADMIUM	1.35	1.16	0.19	0.54	0.81
119 CHROMIUM	1729.15	1728.87	0.28	1728.33	0.82
120 COPPER	0.27	0.00	0.27	0.00	0.27
121 CYANIDE	2.46	2.27	0.19	1.74	0.72
122 LEAD	12.67	12.35	0.32	11.43	1.24
124 NICKEL	11.86	10.99	0.87	5.99	5.87
128 ZINC	765.18	764.27	0.91	762.09	3.09
TOXIC ORG.	3.54	3.45	0.09	3.31	0.23
IRON	84.93	83.83	1.10	80.71	4.22
PHOSPHORUS	443.04	432.32	10.72	401.02	42.02
OIL & GREASE	1590.01	1550.61	39.40	1487.01	103.00
TSS	3423.78	3413.54	10.24	3300.18	123.60
TOXIC METALS	2520.48	2517.64	2.84	2508.38	12.10
CONVENTIONALS	5013.79	4964.15	49.64	4787.19	226.60
TOTAL TOXICS	2526.48	2523.36	3.12	2513.43	13.05
TOTAL POLLU.	8068.24	8003.66	64.58	7782.35	285.89
SLUDGE GEN		62496.07		60546.82	

TABLE XI-4
POLLUTANT REDUCTION BENEFITS OF CONTROL SYSTEMS
ALUMINUM SUBCATEGORY - NORMAL PLANT

PARAMETER	RAW WASTE	Final NSPS (PSNS)		Final BAT (PSES)	
		Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
FLOW 1/yr (10^6)	97.80		13.81		28.70
118 CADMIUM	0.49	0.00	0.49	0.00	0.49
119 CHROMIUM	4254.30	4253.33	0.97	4252.00	2.30
120 COPPER	4.21	0.00	4.21	0.00	4.21
121 CYANIDE	55.55	54.90	0.65	53.54	2.01
122 LEAD	11.54	10.44	1.10	8.10	3.44
124 NICKEL	0.29	0.00	0.29	0.00	0.29
128 ZINC	2.74	0.00	2.74	0.00	2.74
TOXIC ORG.	6.85	6.68	0.17	6.51	0.34
ALUMINUM	10974.33	10964.11	10.22	10942.47	31.86
IRON	337.21	333.34	3.87	325.44	11.77
PHOSPHORUS	684.60	647.04	37.56	567.50	117.10
OIL & GREASE	5629.47	5491.37	138.10	5342.47	287.00
TSS	8301.66	8265.75	35.91	7957.26	344.40
TOXIC METALS	4273.57	4263.77	9.8	4260.10	13.47
CONVENTIONALS	13931.13	13757.12	174.01	13299.73	631.40
TOTAL TOXICS	4335.97	4325.35	10.62	4320.15	15.82
TOTAL POLLU.	30263.24	30026.96	236.28	29455.29	807.95
SLUDGE GEN		445730.54		440651.42	

TABLE XI-5
NEW SOURCE PERFORMANCE STANDARDS
STEEL SUBCATEGORY

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2	$(lb/1,000,000\ ft^2)$	mg/m^2	$(lb/1,000,000\ ft^2)$
CADMIUM	0.063	(0.013)	0.025	(0.005)
*CHROMIUM	0.117	(0.024)	0.047	(0.010)
COPPER	0.404	(0.083)	0.193	(0.040)
*CYANIDE	0.063	(0.013)	0.025	(0.005)
LEAD	0.032	(0.007)	0.028	(0.006)
NICKEL	0.174	(0.036)	0.117	(0.024)
*ZINC	0.322	(0.066)	0.133	(0.027)
*IRON	0.389	(0.080)	0.199	(0.041)
*OIL & GREASE	3.160	(0.647)	3.160	(0.647)
*TSS	4.740	(0.971)	3.476	(0.712)
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			

TABLE XI-6
NEW SOURCE PERFORMANCE STANDARDS
GALVANIZED SUBCATEGORY

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2	$(lb/1,000,000\ ft^2)$	mg/m^2	$(lb/1,000,000\ ft^2)$
CADMIUM	0.069	(0.014)	0.027	(0.006)
*CHROMIUM	0.127	(0.026)	0.051	(0.010)
*COPPER	0.439	(0.090)	0.209	(0.043)
*CYANIDE	0.069	(0.014)	0.027	(0.006)
LEAD	0.034	(0.007)	0.031	(0.006)
NICKEL	0.189	(0.039)	0.127	(0.026)
*ZINC	0.350	(0.072)	0.144	(0.029)
*IRON	0.422	(0.086)	0.216	(0.044)
*OIL & GREASE	3.430	(0.703)	3.430	(0.703)
*TSS	5.145	(1.054)	3.773	(0.773)
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE XI-7
NEW SOURCE PERFORMANCE STANDARDS
ALUMINUM SUBCATEGORY

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2	($lb/1,000,000\ ft^2$)	mg/m^2	($lb/1,000,000\ ft^2$)
CADMIUM	0.095	(0.019)	0.038	(0.008)
*CHROMIUM	0.176	(0.036)	0.071	(0.015)
COPPER	0.608	(0.125)	0.290	(0.059)
*CYANIDE	0.095	(0.019)	0.038	(0.008)
LEAD	0.048	(0.010)	0.043	(0.009)
NICKEL	0.261	(0.053)	0.176	(0.036)
*ZINC	0.485	(0.099)	0.200	(0.041)
*ALUMINUM	1.439	(0.295)	0.589	(0.121)
IRON	0.584	(0.120)	0.299	(0.061)
*OIL & GREASE	4.750	(0.973)	4.750	(0.973)
*TSS	7.125	(1.459)	5.225	(1.070)
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			

* THIS POLLUTANT IS REGULATED AT PROMULGATION

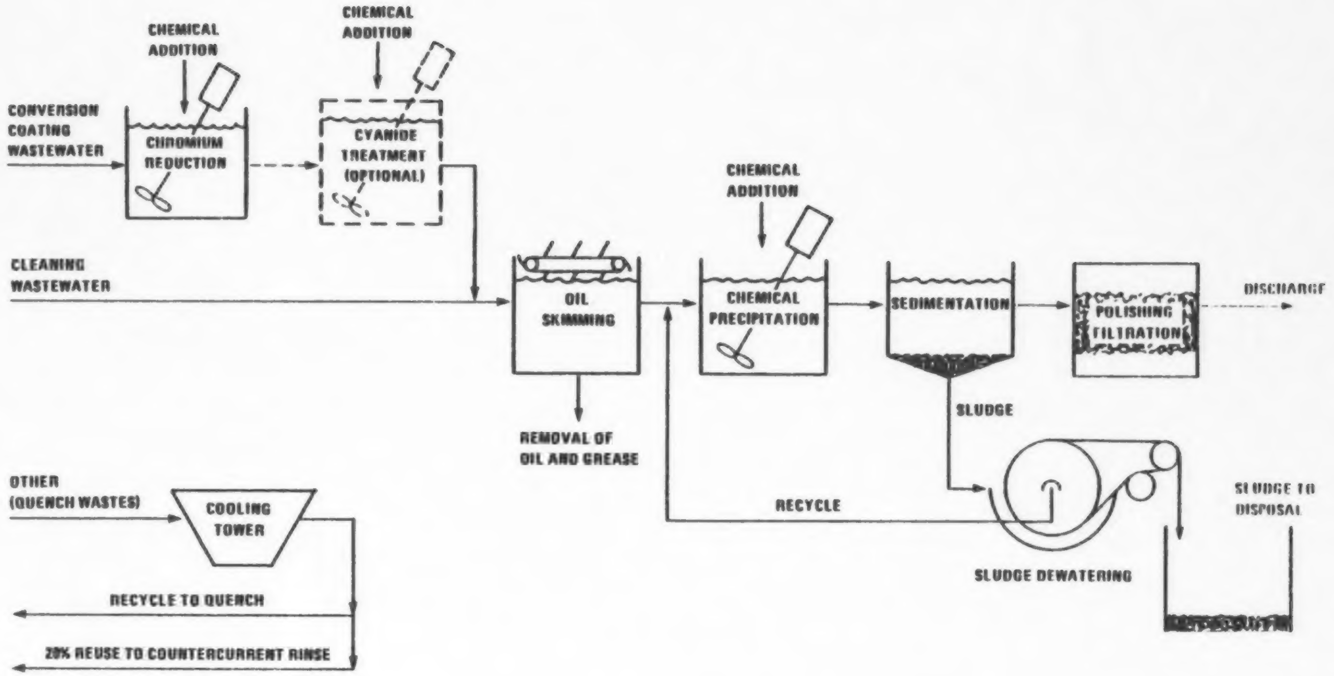

CHEMICAL ADDITION
CHEMICAL ADDITION
CONVERSION COATING WASTEWATER
CHROMIUM REDUCTION
CYANIDE TREATMENT (OPTIONAL)
CHEMICAL ADDITION
CLEANING WASTEWATER
OIL SKIMMING
CHEMICAL PRECIPITATION
SEDIMENTATION
POLISHING FILTRATION
DISCHARGE
SLUDGE
REMOVAL OF OIL AND GREASE
OTHER (QUENCH WASTES)
COOLING TOWER
RECYCLE
SLUDGE TO DISPOSAL
SLUDGE DEWATERING
RECYCLE TO QUENCH
20% REUSE TO COUNTERCURRENT RINSE

FIGURE XI-1. BDT LEVEL 1 WASTEWATER TREATMENT SYSTEM

SECTION XII

PRETREATMENT

The model control technologies for pretreatment of process wastewaters from existing sources and new sources are described. An indirect discharger is defined as a facility which introduces pollutants into a publicly owned treatment works (POTW).

PSES are designed to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of publicly owned treatment works (POTW). They must be achieved within three years of promulgation. The Clean Water Act of 1977 requires pretreatment for pollutants that pass through the POTW in amounts that would violate direct discharger effluent limitations or interfere with the POTW's treatment process or chosen sludge disposal method. The legislative history of the 1977 Act indicates that pretreatment standards are to be technology-based, analogous to the best available technology for removal of toxic pollutants. The general pretreatment regulation, which served as the framework for this pretreatment regulation is found at 40 CFR Part 403.

Like PSES, PSNS are to prevent the discharge of pollutants which pass through, interfere with, or are otherwise incompatible with the operation of the POTW. PSNS are to be issued at the same time as NSPS. New indirect dischargers, like new direct dischargers, have the opportunity to incorporate the best available demonstrated technologies. The Agency considers the same factors in promulgating PSNS as it considers in promulgating PSES.

Most POTW consist of primary or secondary treatment systems which are designed to treat domestic wastes. Many of the pollutants contained in coil coating wastes are not biodegradable and are therefore ineffectively treated by such systems. Furthermore, these wastes have been known to interfere with the normal operations of these systems. Problems associated with the uncontrolled release of pollutant parameters identified in coil coating process wastewaters to POTW were discussed in Section VI. The pollutant-by-pollutant discussion covered pass through, interference, and sludge usability. EPA has generally determined there is pass through of pollutants if the percent of pollutants removed by a well operated POTW achieving secondary treatment is less than the percent removed by the BAT model treatment technology. POTW removals of the major toxic pollutants found in coil coating wastewater are presented in Table XII-1. The average removal of toxic metals is about 31 percent. The BAT treatment technology removes more than 99 percent of toxic metals (see Table X-16, page 424). This difference in removal effectiveness clearly indicates pass through of toxic metals will occur unless coil coating wastewaters are adequately pretreated.

The Agency found small amounts of several toxic organics in coil coating wastewaters. The Agency considered and analyzed whether these pollutants should be specifically regulated.

The average removal of toxic organics is about 70 percent by a secondary POTW (Table XII-1, page 451). The treatment technology for organics removal is oil skimming. The percent removal of organics by oil skimming from five coil coating plant sampling days is presented in Section VII. The average removal of organics by oil skimming in this category is about 84 percent. Clearly there is pass through of about 0.2 mg/l of total toxic organics (TTO). On the other hand, the raw waste level of TTO in the coil category is only about 1.47 mg/l (See Table X-4, page 412). The Agency's concludes that the treatment effected by POTW reduces the small amount and the toxicity of organics below the level that would require national regulation.

The model treatment technology system for pretreatment at existing sources (PSES) is the same as the BAT treatment system. (See Figure X-2). The model treatment system for new sources (PSNS) is the same as BDT for NSPS. (See Figure XI-1). These model technologies were selected for the reasons explained in the BAT and NSPS sections. The modifications made to the proposed PSES and PSNS are the same as the modifications made to the proposed BAT and NSPS, respectively. Oil skimming is included in the PSES and PSNS control technologies, benefits, and costs. The Agency believes oil and grease removal may be needed to meet the toxic metals limitations since oil and grease can interfere with the removal of precipitated metals. For PSES and PSNS, the toxic metals which intefere with, pass through or prevent sludge utilization for food crops must be removed before discharge to the POTW. PSES and PSNS includes hexavalent chromium reduction to render the chromium removable by precipitation and sedimentation and cyanide removal to prevent complexing of toxic metals that hinder further treatment. Toxic metals are removed by pH adjustment and settling for PSES and by pH adjustment, settling, and filtration for PSNS. Flow reduction measures (quench recycle and reuse for both and countercurrent rinse for PSNS) are retained to provide minimum mass discharge of toxic pollutants. If conventional conversion coating is used for PSNS, there is no allowance for additional discharge from coating operations.

Industry Cost and Effluent Reduction of Treatment Options

PSES Options 1 and 2 are parallel to BAT Options 1 and 2. Also, PSNS Options are parallel to the NSPS Options. Estimates of capital and annual costs for BAT-PSES option and NSPS-PSNS options were prepared for each subcategory as an aid to choosing the best options. Results for BAT-PSES are presented in Table X-18 and results for NSPS-PSNS are presented in Table XI-1. All costs are based on January 1978 dollars.

PSES pollutant reduction benfits for each subcategory were derived by applying the percentage of production attributable to indirect dischargers. The pollutant reduction benefits for the subcategories and the category are presented in Table XII-1 through XII-4 (pages 451-454). Table XII-5 summarizes treatment performances by subcategory and by category for each PSES option. All pollutant parameters calculations were based on median raw wastewater concentrations for visited plants (Table V-31, page 103). The term "toxic organics" refers to toxic organics listed in Table X-4 (page 412).

PSNS pollutant reduction benefits for each subcategory were based on a normal plant production. The normal plant production for the steel, galvanized and aluminum subcategories are 12.19, 11.50 and 29.08 million sq meters per year, respectively. The pollutant reduction benefits for each subcategory are presented in Tables XI-2 through XI-4. All pollutant parameter calculations were based on median raw wastewater concentrations for visited plants (Table V-31, page 103). The term "toxic organics" refers to toxic organics listed in Table X-4 (page 412).

Regulated Pollutant Parameters

The Agency reviewed the coil coating wastewater concentrations, the BAT model treatment technology removals, and the POTW removals of major toxic pollutants found in coil coating wastewaters to select the pollutants for regulation. The pollutants to be regulated are the same for each subcategory as were selected for BAT except that the nonconventional pollutants (aluminum and iron) are not regulated because POTW remove these pollutant parameters. Aluminum and iron compounds are frequently used as flocculation aids in POTW. Toxic metals are regulated to prevent pass through. Toxic organics are not regulated because POTW reduce the small amount and toxicity below the level requiring national regulation.

PRETREATMENT STANDARDS

Mass based limitations are set forth below (Tables XII-7 through XII-12, pages 457-459). The mass based limitations are the only method of designating pretreatment standards since the water flow reductions at PSES and PSNS are major features of the treatment and control system. Only mass-based limits will assure the implementation of flow reduction and the consequent reduction if the quantity of pollutants discharged. Therefore, to regulate concentrations is not adequate. Standards for existing sources are presented first, by subcategory; then standards for new sources are presented by subcategory.

The derivation of standards is explained in Section IX (page 483). The mean water use for each subcategory at PSES is equal to the mean water use for each subcategory at BAT and their derivation is presented in Section X (pages 405, 406 and 407). For PSNS, the calculation is the same, except the lime, settle andfilter treatment effectivenesses and the PSNS Mean water uses are used. The lime, settle and filter treatment effectiveness are developed in Section VII. The mean water use for each subcategory at PSNS is equal to the mean water use for each subcategory at NSPS.

DEMONSTRATION STATUS

Since the model treatment technologies for PSES and PNSN are the same as BAT and NSPS, respectively, the demonstration status is the same as for BAT and NSPS (See Sections X and XI).

TABLE XII-1

POTW REMOVALS OF THE MAJOR TOXIC POLLUTANTS FOUND IN COIL COATING WASTEWATER

	Pollutant	Percent Removal By Secondary POTW
11	1,1,1-Trichloroethane	87
13	1,1-Dichloroethane	76
29	1,1-Dichloroethylene	80
30	1,2-Trans-Dichloroethylene	72
34	2,4-Dimethylphenol	59
39	Fluoranthene	NA
54	Isophorone	NA
55	Naphthalene	61
65	Phenol	96
66	Bis (2-ethylhexyl) phthalate	62
67	Butyl-benzyl phthalate	59
68	Di-n-butylphthalate	48
69	Di-n-octyl phthalate	81
70	Diethyl phthalate	74
71	Dimethyl phthalate	50
72	1,2-Benzanthracene	NA
73	Benzo (a) pyrene	NA
74	3,4-Benzofluoranthene	NA
75	11,12-Benzofluoranthene	NA
76	Chrysene	NA
77	Acenaphthalene	NA
78	Anthracene	65
79	1,12-Benzoperylene	83
80	Fluorene	NA
81	Phenathrene	65
82	1,2,5,6-Dibenzanthracene	NA
83	Indeno (1,2,3-cd)pyrene	NA
84	Pyrene	40
86	Toluene	90
87	Trichloroethylene	85
118	Cadmium	38
119	Chromium, hexavalent	18
	Chromium, trivalent	NA
120	Copper	58
121	Cyanide	52
122	Lead	48
124	Nickel	19
128	Zinc	65

NA Not Available

NOTE: This data compiled from Fate Of Priority Pollutants In Publicly Owned Treatment Works, USEPA, EPA No. 440/1-80-301, October 1980.

TABLE XII-2
TREATMENT PERFORMANCE - INDIRECT DISCHARGERS
STEEL SUBCATEGORY

PARAMETER	RAW WASTE	PSES 0		PSES 1		PSES 2	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	905.77		905.77		386.07		386.07
118 CADMIUM	0.91	0.00	0.91	0.00	0.91	0.00	0.91
119 CHROMIUM	6218.11	6145.65	72.46	6187.22	30.89	6191.09	27.02
120 COPPER	46.19	0.00	46.19	0.00	46.19	0.00	46.19
121 CYANIDE	10.87	0.00	10.87	0.00	10.87	0.00	10.87
122 LEAD	128.62	19.93	108.69	82.29	46.33	97.73	30.89
124 NICKEL	355.06	0.00	355.06	135.00	220.06	270.12	84.94
128 ZINC	6872.98	6601.25	271.73	6757.16	115.82	6784.18	88.80
TOXIC ORG.	1161.20	1126.78	34.42	1146.53	14.67	1146.53	14.67
IRON	9189.04	8817.67	371.37	9030.75	158.29	9080.94	108.10
PHOSPHORUS	38833.98	35138.44	3695.54	37258.81	1575.17	37783.87	1050.11
OIL & GREASE	309456.32	300398.62	9057.70	305595.62	3860.70	305595.62	3860.70
TSS	138392.60	127523.36	10869.24	133759.76	4632.84	137388.82	1003.78
TOXIC METALS	13621.87	12766.83	855.04	13161.67	460.20	13343.12	278.75
CONVENTIONALS	447848.92	427921.98	19926.94	439355.38	8493.54	442984.44	4864.48
TOTAL TOXICS	14793.94	13893.61	900.33	14308.20	485.74	14489.65	304.29
TOTAL POLLU.	510665.88	485771.70	24894.18	499953.14	10712.74	504338.90	6326.98
SLUDGE GEN		3246002.32		3366389.95		3403677.48	

TABLE XII-3
TREATMENT PERFORMANCE - INDIRECT DISCHARGERS
GALVANIZED SUBCATEGORY

PARAMETER	RAW WASTE	PSES 0		PSES 1		PSES 2	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	510.26		510.26		175.17		175.17
118 CADMIUM	22.96	0.00	22.96	9.12	13.84	14.38	8.58
119 CHROMIUM	29390.98	29350.16	40.82	29376.97	14.01	29378.72	12.26
120 COPPER	4.59	0.00	4.59	0.00	4.59	0.00	4.59
121 CYANIDE	41.84	6.12	35.72	29.58	12.26	33.61	8.23
122 LEAD	215.33	154.10	61.23	194.31	21.02	201.32	14.01
124 NICKEL	201.55	0.00	201.55	101.70	99.85	163.01	38.54
128 ZINC	13006.02	12852.94	153.08	12953.47	52.55	12965.73	40.29
TOXIC ORG.	60.21	48.98	11.23	56.36	3.85	56.36	3.85
IRON	1443.53	1234.32	209.21	1371.71	71.82	1394.48	49.05
PHOSPHORUS	7530.42	5448.56	2081.86	6815.73	714.69	7053.96	476.46
OIL & GREASE	27025.92	21923.32	5102.60	25274.22	1751.70	25274.22	1751.70
TSS	58195.15	52072.03	6123.12	56093.11	2102.04	57739.71	455.44
TOXIC METALS	42841.43	42357.20	484.23	42635.57	205.86	42723.16	118.27
CONVENTIONALS	85221.07	73995.35	11225.72	81367.33	3853.74	83013.93	2207.14
TOTAL TOXICS	42943.48	42412.30	531.18	42721.51	221.97	42813.13	130.35
TOTAL POLLU.	137138.50	123090.53	14047.97	132276.28	4862.22	134275.50	2863.00
SLUDGE GEN		950021.55		1029104.61		1046212.99	

TABLE XII-4
TREATMENT PERFORMANCE - INDIRECT DISCHARGERS
ALUMINUM SUBCATEGORY

PARAMETER	RAW WASTE	PSES 0		PSES 1		PSES 2	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	2444.90		2444.90		717.55		717.55
118 CADMIUM	12.22	0.00	12.22	0.00	12.22	0.00	12.22
119 CHROMIUM	106353.15	106157.56	195.59	106295.75	57.40	106302.92	50.23
120 COPPER	105.13	0.00	105.13	0.00	105.13	0.00	105.13
121 CYANIDE	1388.70	1217.56	171.14	1338.47	50.23	1354.98	33.72
122 LEAD	288.50	0.00	288.50	202.39	86.11	231.10	57.40
124 NICKEL	7.33	0.00	7.33	0.00	7.33	0.00	7.33
128 ZINC	68.46	0.00	68.46	0.00	68.46	0.00	68.46
TOXIC ORG.	171.14	141.80	29.34	162.53	8.61	162.53	8.61
ALUMINUM	274347.12	271633.28	2713.84	273550.64	796.48	273816.13	530.99
IRON	8430.02	7427.61	1002.41	8135.82	294.20	8229.11	200.91
PHOSPHORUS	17114.30	7139.11	9975.19	14186.70	2927.60	15162.56	1951.74
OIL & GREASE	140730.89	116281.89	24449.00	133555.39	7175.50	133555.39	7175.50
TSS	207532.89	178194.09	29338.80	198922.29	8610.60	205667.26	1865.63
TOXIC METALS	106834.79	106157.56	677.23	106498.14	336.65	106534.02	300.77
CONVENTIONALS	348263.78	294475.98	53787.80	332477.68	15786.10	339222.65	9041.13
TOTAL TOXICS	108394.63	107516.92	877.71	107999.14	395.49	108051.53	343.10
TOTAL POLLU.	756549.85	688192.90	68356.95	736349.98	20199.87	744481.98	12067.87
SLUDGE GEN		10578125.92		11015823.13		11083649.34	

TABLE XII-5
TREATMENT PERFORMANCE - INDIRECT DISCHARGERS
TOTAL CATEGORY

PARAMETER	RAW WASTE	PSES 0		PSES 1		PSES 2	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW l/yr (10^6)	3860.93		3860.93		1278.79		1278.79
118 CADMIUM	36.09	0.00	36.09	9.12	26.97	14.38	21.71
119 CHROMIUM	141962.24	141653.37	308.87	141859.94	102.30	141872.73	89.51
120 COPPER	155.91	0.00	155.91	0.00	155.91	0.00	155.91
121 CYANIDE	1441.41	1223.68	217.73	1368.05	73.36	1388.59	52.82
122 LEAD	632.45	174.03	458.42	478.99	153.46	530.15	102.30
124 NICKEL	563.94	0.00	563.94	236.70	327.24	433.13	130.81
128 ZINC	19947.46	19454.19	493.27	19710.63	236.83	19749.91	197.55
TOXIC ORG.	1392.55	1317.56	74.99	1365.42	27.13	1365.42	27.13
ALUMINUM	274347.12	271633.28	2713.84	273550.64	796.48	273816.13	530.99
IRON	19062.59	17479.60	1582.99	18538.28	524.31	18704.53	358.06
PHOSPHORUS	63478.70	47726.11	15752.59	58261.24	5217.46	60000.39	3478.31
OIL & GREASE	477213.13	438603.83	38609.30	464425.23	12787.90	464425.23	12787.90
TSS	404120.64	357789.48	46331.16	388775.16	15345.48	400795.79	3324.85
TOXIC METALS	163298.09	161281.59	2016.50	162295.38	1002.71	162600.30	697.79
CONVENTIONALS	881333.77	796393.31	84940.46	853200.39	28133.38	865221.02	16112.75
TOTAL TOXICS	166132.05	163822.83	2309.22	165028.85	1103.20	165354.31	777.74
TOTAL POLLU.	1404354.23	1297055.13	107299.10	1368579.40	35774.83	1383096.38	21257.85
SLUDGE GEN		14774149.79		15411317.69		15533539.81	

TABLE XII-6
SUMMARY TABLE
POLLUTANT REDUCTION BENEFITS
INDIRECT DISCHARGERS

	RAW WASTE	PSES 0		PSES 1		PSES 2	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
Steel Subcategory							
TOXIC METALS	13621.87	12766.83	855.04	13161.67	460.20	13343.12	278.75
CONVENTIONALS	447848.92	427921.98	19926.94	439355.38	8493.54	442984.44	4864.48
TOTAL TOXICS	14793.94	13893.61	900.33	14308.20	485.74	14489.65	304.29
TOTAL POLLU.	510665.88	485771.70	24894.18	499953.14	10712.74	504338.90	6326.98
Galvanized Subcategory							
TOXIC METALS	42841.43	42357.20	484.23	42635.57	205.86	42723.16	118.27
CONVENTIONALS	85221.07	73995.35	11225.72	81367.33	3853.74	83013.93	2207.14
TOTAL TOXICS	42943.48	42412.30	531.18	42721.51	221.97	42813.13	130.35
TOTAL POLLU.	137138.50	123090.53	14047.97	132276.28	4862.22	134275.50	2863.00
Aluminum Subcategory							
TOXIC METALS	106834.79	106157.56	677.23	106498.14	336.65	106534.02	300.77
CONVENTIONALS	348263.78	294475.98	53787.80	332477.68	15786.10	339222.65	9041.13
TOTAL TOXICS	108394.63	107516.92	877.71	107999.14	395.49	108051.53	343.10
TOTAL POLLU.	756549.85	688192.90	68356.95	736349.98	20199.87	744481.98	12067.87
Total Subcategory							
TOXIC METALS	163298.09	161281.59	2016.50	162295.38	1002.71	162600.30	697.79
CONVENTIONALS	881333.77	796393.31	84940.46	853200.39	28133.38	865221.02	16112.75
TOTAL TOXICS	166132.05	163822.83	2309.22	165028.85	1103.20	165354.31	777.74
TOTAL POLLU.	1404354.23	1297055.13	107299.10	1368579.40	35774.83	1383096.38	21257.85

TABLE XII-7
PRETREATMENT STANDARDS FOR EXISTING SOURCES
STEEL SUBCATEGORY

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2	$(lb/1,000,000\ ft^2)$	mg/m^2	$(lb/1,000,000\ ft^2)$
CADMIUM	0.375	(0.077)	0.176	(0.036)
*CHROMIUM	0.493	(0.101)	0.199	(0.041)
COPPER	2.229	(0.457)	1.173	(0.240)
*CYANIDE	0.340	(0.070)	0.141	(0.029)
LEAD	0.176	(0.036)	0.152	(0.031)
NICKEL	1.654	(0.339)	1.173	(0.240)
*ZINC	1.560	(0.320)	0.657	(0.135)

TABLE XII-8
PRETREATMENT STANDARDS FOR EXISTING SOURCES
GALVANIZED SUBCATEGORY

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2	$(lb/1,000,000\ ft^2)$	mg/m^2	$(lb/1,000,000\ ft^2)$
CADMIUM	0.287	(0.059)	0.134	(0.027)
*CHROMIUM	0.376	(0.077)	0.152	(0.031)
*COPPER	1.702	(0.349)	0.896	(0.184)
*CYANIDE	0.260	(0.053)	0.108	(0.022)
LEAD	0.134	(0.027)	0.116	(0.024)
NICKEL	1.263	(0.259)	0.896	(0.184)
*ZINC	1.192	(0.244)	0.502	(0.103)

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE XII-9
PRETREATMENT STANDARDS FOR EXISTING SOURCES
ALUMINUM SUBCATEGORY

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2	$(lb/1,000,000\ ft^2)$	mg/m^2	$(lb/1,000,000\ ft^2)$
CADMIUM	0.316	(0.065)	0.148	(0.030)
*CHROMIUM	0.415	(0.085)	0.168	(0.034)
COPPER	1.875	(0.384)	0.987	(0.202)
*CYANIDE	0.286	(0.059)	0.118	(0.024)
LEAD	0.148	(0.030)	0.128	(0.026)
NICKEL	1.392	(0.285)	0.987	(0.202)
*ZINC	1.313	(0.269)	0.553	(0.113)

TABLE XII-10
PRETREATMENT STANDARDS FOR NEW SOURCES
STEEL SUBCATEGORY

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2	$(lb/1,000,000\ ft^2)$	mg/m^2	$(lb/1,000,000\ ft^2)$
CADMIUM	0.063	(0.013)	0.025	(0.005)
*CHROMIUM	0.117	(0.024)	0.047	(0.010)
COPPER	0.404	(0.083)	0.193	(0.040)
*CYANIDE	0.063	(0.013)	0.025	(0.005)
LEAD	0.032	(0.007)	0.028	(0.006)
NICKEL	0.174	(0.036)	0.117	(0.024)
*ZINC	0.322	(0.066)	0.133	(0.027)

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE XII-11
PRETREATMENT STANDARDS FOR NEW SOURCES
GALVANIZED SUBCATEGORY

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2	($lb/1,000,000\ ft^2$)	mg/m^2	($lb/1,000,000\ ft^2$)
CADMIUM	0.069	(0.014)	0.027	(0.006)
*CHROMIUM	0.127	(0.026)	0.051	(0.010)
*COPPER	0.439	(0.090)	0.209	(0.043)
*CYANIDE	0.069	(0.014)	0.027	(0.006)
LEAD	0.034	(0.007)	0.031	(0.006)
NICKEL	0.189	(0.039)	0.127	(0.026)
*ZINC	0.350	(0.072)	0.144	(0.029)

TABLE XII-12
PRETREATMENT STANDARDS FOR NEW SOURCES
ALUMINUM SUBCATEGORY

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2	($lb/1,000,000\ ft^2$)	mg/m^2	($lb/1,000,000\ ft^2$)
CADMIUM	0.095	(0.019)	0.038	(0.008)
*CHROMIUM	0.176	(0.036)	0.071	(0.015)
COPPER	0.608	(0.125)	0.290	(0.059)
*CYANIDE	0.095	(0.019)	0.038	(0.008)
LEAD	0.048	(0.010)	0.043	(0.009)
NICKEL	0.261	(0.053)	0.176	(0.036)
*ZINC	0.485	(0.099)	0.200	(0.041)

* THIS POLLUTANT IS REGULATED AT PROMULGATION

SECTION XIII

BEST CONVENTIONAL POLLUTANT CONTROL TECHNOLOGY

INTRODUCTION

The 1977 Amendments added Section 301(b)(2)(E) to the Act establishing "best conventional pollutant control technology" [BCT] for discharges of conventional pollutants from existing industrial point sources. Conventional pollutants are those defined in Section 304(a)(4) [biological oxygen demanding pollutants (BOD%), total suspended solifs (TSS), fecal coliform, and pH], and any addittional pollutants defined by the Administrator as "conventional" [oil and grease, 44 FR 44501, July 30, 1979].
BCT is not an additional limitation but replaces BAT for the control of conventional pollutants. In addition to other factors specified in section 304(b)(4)(B), the Act requies that BCT limitations be assessed in light of a two part "cost-reasonableness" test. American Paper Institute v. EPA, 660 F.2d 954 (4th Cir. 1981). The first test compares the cost for private industry to reduce its conventional pollutants with the costs to publicly owned treatment works for similar levels of reduction in their discharge of these pollutants. The second test examines the cost-effectiveness of additional industrial treatment beyond BPT. EPA must find that limitations are "reasonable" under both tests before establishing them as BCT. In no case may BCT be less stringent than BPT.

EPA first published its methodology for carrying out the BCT analysis on August 29, 1979 (44 FR 50732). In the case mentioned above, the Court of Appeals ordered EPA to correct data errors underlying EPA's claculation of the first test, and to apply the second cost test. (EPA had argued that a second cost test was not required.)

EPA has determined that the BAT technology is capable of removing significant amounts of conventional pollutants. However, EPA has not yet promulgated a revised BCT methodology in response to the American Paper Institute v. EPA decision mentioned earlier. EPA is deferring a decision on the appropriate BCT limitations.

SECTION XIV

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SECTION XVI

GLOSSARY

Accumulation - In reference to biological systems, is the concentration which collects in a tissue or organism which does not disappear with time.

Accumulator or Looper - A series of fixed and movable rolls which serves as a reservoir of basis material in a continuous coating line. Their purpose is to provide enough basis material to avoid shutting down the line when attaching a new roll or removing a completed one.

Acidity - The quantitative capacity of aqueous media to react with hydroxyl ions.

Acidulated Rinse - See Sealing Rinse

Act - The Federal Water Pollution Control Act (P.L. 92-500) as amended by the Clean Water Act of 1977 (P.L. 95-217).

Activator - A material that enhances the chemical or physical change on the coated coil surface.

Adsorption - The adhesion of an extremely thin layer of molecules of a gas or liquid to the surface of the solid or liquid with which they are in contact.

Agency - The U.S. Environmental Protection Agency.

Air Drying - A process whereby the coil is dried by air before proceeding to the next process step.

Air Knife - A device with air jets to permit the use of hot or ambient air to control dragout and temperature

Algicide - Chemical used in the control of phytoplankton (algae) in water.

Alkaline Cleaning - A process where mineral deposits, animal fats and oils are removed from the bare metal surface of a coil. Solutions containing caustic soda, soda ash, alkaline silicates, alkaline phosphates and ionic and nonionic detergents are commonly used.

Alkalinity - The quantitative capacity of aqueous media to react with hydrogen ions.

Aluminum Basis Material - Means aluminum, aluminum alloys and aluminum coated steels which are processed in coil coating.

Anionic Surfactant - An ionic type of surface-active substance that has been widely used in cleaning products. The hydrophilic group of these surfactants carries a negative charge in the washing solution.

Anodizing - An electrochemical process of controlled aluminum oxidation producing a hard, transparent oxide up to several mils in thickness.

Applicator Roll - The roll in a roll coater which applies the paint, conversion coat, or other liquid to a moving strip of metal.

Area Processed - See Processed Area.

Backwashing - The process of cleaning a filter or ion exchange column by reversing the flow of water.

Baffles - Deflector vanes, guides, grids, gratings, or similar devices constructed or placed in flowing water or sewage to (1) check or effect a more uniform distribution of velocities; (2) absorb energy; (3) divert, guide, or agitate the liquids; or (4) check eddy currents.

Baking - A drying or curing process carried out in an enclosure where the temperature is maintained in excess of 150°C.

Basis Material or Metal - That substance of which the workpieces are made and that receives the coating and the treatments in preparation of coating.

BAT - The best available technology economically achievable under Section 304(b)(2)(B) of the Act

BCT - The best conventional pollutant control technology, under Section 304(b)(4) of the Act

BDT - The best available demonstrated control technology processes, operating methods, or other alternatives, including where practicable, a standard permitting no discharge of pollutants under Section 306(a)(1) of the Act.

Biochemical Oxygen Demand (BOD) - (1) The quantity of oxygen required for the biological and chemical oxidation of waterborne substances under conditions of test used in the biochemical oxidation of organic matter in a specified time, at a specified temperature, and under specified conditions. (2) Standard test used in assessing wastewater strength.

Biodegradable - The part of organic matter which can be oxidized by bioprocesses, e.g., biodegradable detergents, food wastes, animal manure, etc.

Biological Wastewater Treatment - Forms of wastewater treatment in which bacteria or biochemical action is intensified to stabilize, oxidize, and nitrify the unstable organic matter present.

BMP - Best management practices under Section 304(e) of the Act

BPT - The best practicable control technology currently available under Section 304(b)(1) of the Act.

Buffer - Any of certain combinations of chemicals used to stabilize the pH values or alkalinities of solutions.

Cake - The material resulting from drying or dewatering sludge.

Calibration - The determination, checking, or rectifying of the graduation of any instrument giving quantitative measurements.

Captive Operation - A manufacturing operation carried out in a facility to support other manufacturing, fabrication, or assembly operations.

Carcinogenic - Referring to the ability of a substance to produce or incite cancer.

Central Treatment Facility - Treatment plant which co-treats process wastewaters from more than one manufacturing operation or cotreats process wastewaters with noncontact cooling water, or with non-process wastewaters. laneous runoff, etc.).

Chemical Coagulation - The destabilization and initial aggregation of colloidal and finely divided suspended matter by the addition of a floc-forming chemical. The amount of oxygen expressed in parts per million consumed under specific conditions in the oxidation of the organic and oxidizable inorganic matter contained in an industrial wastewater corrected for the influence of chlorides.

Chemical Oxygen Demand (COD) - (1) A test based on the fact that all organic compounds, with few exceptions, can be oxidized to carbon dioxide and water by the action of strong oxidizing agents under acid conditions. Organic matter is converted to carbon dioxide and water regardless of the biological assimilability of the substances. One of the chief limitations is its ability to differentiate between biologically oxidizable and biologically inert organic matter. The major advantage of this test is the short time required for evaluation (2 hrs). (2) The amount of oxygen required for the chemical oxidation of organics in a liquid.

Chemcial Oxidation - A wastewater treatment in which a pollutant is oxidized.

Chemical Precipitation - Precipitation induced by addition of chemicals.

Chlorination - The application of chlorine to water or wastewater generally for the purpose of disinfection, but frequently for accomplishing other biological or chemical results.

Chromate Conversion Coating - A process whereby an aqueous acidified chromate solution consisting mostly of chromic acid and water soluble salts of chromic acid together with various catalysts or activators (such as cyanide) is applied to the coil.

Chromium Process Controller - A device used to maintain a desirable and constant hexavalent chromium concentration.

Clarification - The removal of suspended solids from wastewater.

Cleaning - The process of removing contaminants from the surface of a coil.

Clean Water Act - The Federal Water Pollution Control Act Amendments of 1972 (33 U.S.C. 1251 et seq.), as amended by the Clean Water Act of 1977 (Public Law 95-217)

Coil - Means a strip of basis material rolled into a roll for handling.

Coil Coating - A process of applying a protective coating to a coil which involves at least two of the following operations: cleaning, conversion coating, and painting.

Colloids - A finely divided dispersion of one material called the "dispersed phase" (solid) in another material which is called the "dispersion medium" (liquid). Normally negatively charged.

Compatible Pollutant - A specific substance in a waste stream which alone can create a potential pollution problem, yet is used to the advantage of a certain treatment process when combined with other wastes.

Composite - A combination of individual samples of water or wastewater taken at selected intervals and streams and mixed in proportion to flow or time to minimize the effect of the variability of an individual sample.

Concentration Factor - Refers to the biological concentration factor which is the ratio of the concentration within the tissue or organism to the concentration outside the tissue or organism.

Concentration, Hydrogen Ion - The weight of hydrogen ions in grams per liter of solution. Commonly expressed as the pH value that represents the logarithm of the reciprocal of the hydrogen ion concentration.

Contamination - A general term signifying the introduction of microorganisms, chemicals, wastes or sewage which renders the material or solution unfit for its intended use.

Contractor Removal - The disposal of oils, spent solutions, or sludge by means of a scavenger service.

Conversion Coating - The process of applying a chromate, phosphate, complex oxide or other similar protective coating to a coil.

Cooling Tower - A device used to cool water used in the manufacturing processes before returning the water for reuse.

Curing - A process which follows coating and uses heat to evaporate solvents and prepare the coil for further processing or recoiling.

Degreasing - The process of removing grease and oil from the surface of the coil.

Dewatering - A process whereby water is removed from sludge.

Direct Discharger - A facility which discharges or may discharge pollutants into waters of the United States.

Dissolved Solids - Theoretically the anhydrous residues of the dissolved constituents in water. Actually the term is defined by the method used in determination. In water and wastewater treatment, the Standard Methods tests are used.

Dragout - The solution that adheres to the coil and is carried past the edge of the treatment tank.

Drying Beds - Areas for dewatering of sludge by evaporation and seepage.

Dump - The discharge of process waters not usually discharged for maintenance, depletion of chemicals, etc.

Effluent - The wastewaters which are discharged to surface waters.

Emergency Procedures - The various special procedures necessary to protect the environment from wastewater treatment plant failures due to power outages, chemical spills, equipment failures, major storms and floods, etc.

Emulsion Breaking - Decreasing the stability of dispersion of one liquid in another.

End-of-Pipe Treatment - The reduction and/or removal of pollutants by chemical treatment just prior to actual discharge.

Equalization - The process whereby waste streams from different sources varying in pH, chemical consitutents, and flow rates are collected in a common container. The effluent stream from this equalization tank will have a fairly constant flow and pH level, and will contain a homogeneous chemical mixture.

Feeder, Chemical - A mechanical device for applying chemicals to water and sewage at a rate controlled manually or automatically by the rate of flow.

Float Gauge - A device for measuring the elevation of the surface of a liquid, the actuating element of which is a buoyant float that rests on the surface of the liquid and rises or falls with it. The elevation of the surface is measured by a chain or tape attached to the float.

Floc - A very fine, fluffy mass formed by the aggregation of fine suspended particles.

Flocculator - An apparatus designed for the formation of floc in water or sewage.

Flocculation - In water and wastewater treatment, the agglomeration of colloidal and finely divided suspended matter after coagulation by gentle stirring by either mechanical or hydraulic means. In biological wastewater treatment where coagulation is not used, agglomeration may be accomplished biologically.

Flow-Proportioned Sample - A sampled stream whose pollutants are apportioned to contributing streams in proportion to the flow rates of the contributing streams.

Galvanized Basis Material - Means zinc coated steel, galvanized, brass and other copper base strip which is processed in coil coating.

Grab Sample - A single sample of wastewater taken at neither set time nor flow.

Grease - In wastewater, a group of substances including fats, waxes, free fatty acids, calcium and magnesium soaps, mineral oil, and certain other nonfatty materials. The type of solvent and method used for extraction should be stated for quantification.

Hardness - A characteristic of water, imparted by salts of calcium, magnesium, and iron such as bicarbonates, carbonates, sulfates, chlorides, and nitrates that cause curdling of soap, deposition of scale in boilers, damage in some industrial processes, and sometimes objectionable taste. It may be determined by a standard laboratory procedure or computed from the amounts of calcium and magnesium as well as iron, aluminum, manganese, barium, strontium, and zinc, and is expressed as equivalent calcium carbonate.

Heavy Metals - A general name given to the ions of metallic elements such as copper, zinc, chromium, and nickel.

Holding Tank - A reservoir to contain preparation materials so as to be ready for immediate service.

Indirect Discharger - A facility which introduces or may introduce pollutants into a publicly owned treatment works.

Industrial Wastes - The liquid wastes used directly or indirectly in industrial processes as distinct from domestic or sanitary wastes.

In-Process Control Technology - The regulation and conservation of chemicals and rinse water throughout the operations as opposed to end-of-pipe treatment.

Ion Exchange - A reversible chemical reaction between a solid (ion exchanger) and a fluid (usually a water solution) by means of which ions may be interchanged from one substance to another. The superficial physical structure of the solid is not affected.

Lagoon - A man-made pond or lake for holding wastewater for the removal of suspended solids. Lagoons are also used as retention ponds.

Laminator - A unit which may be included in a coil line to permit the fastening of a film by an adhesive process or a thermoplastic process with or without heat.

Landfill - An approved site for dumping of waste solids.

Lime - Any of a family of chemicals consisting essentially of calcium hydroxide made from limestone (calcite).

Limiting Orifice - A device that limits flow by constriction to a relatively small area. A constant flow can be obtained over a wide range of upstream pressures.

Make-Up Water - Total amount of water used by process.

Milligrams Per Liter (mg/l) - This is a weight per volume designation used in water and wastewater analysis.

Mutagenic - Referring to the ability of a substance to increase the frequency or extent of mutation.

National Pollutant Discharge Elimination System (NPDES) - The federal mechanism for regulating discharge to surface waters by means of permits. A National Pollutant Discharge Elimination System permit issued under Section 402 of the Act.

Neutralization - Chemical addition of either acid or base to a solution such that the pH is adjusted to approximately 7.

Noncontact Cooling Water - Water used for cooling which does not come into direct contact with any raw material, intermediate product, waste product or finished product.

Nonionic Surfactant - A general family of surfactants so called because in solution the entire molecule remains associated. Nonionic molecules orient themselves at surfaces not by an electrical charge, but through separate grease-solubilizing and water-soluble groups within the molecule.

NPDES - National Pollutant Discharge Elimination System.

NSPS - New source performance standards under Section 306 of the Act.

Orthophosphate - An acid or salt containing phosphours as PO$_4$.

Outfall - The point or location where sewage or drainage discharges from a sewer, drain, or conduit.

Paint - A liquid composition of plastic resins, pigments and solvents which is converted to a solid film after application as a thin layer by a drying or heat curing process step.

Painted Area - (Expressed in terms of square meters). The dimensional area that receives an enamel, plastic, vinyl, or laminated coating.

Parshall Flume - A calibrated device developed by Parshall for measuring the flow of liquid in an open conduit. It consists essentially of a contracting length, a throat, and an expanding length. At the throat is a sill over which the flow passes as critical depth. The upper and lower heads are each measured at a definite distance from the sill. The lower head cannot be measured unless the sill is submerged more than about 67 percent.

pH - The negative of the logarithm of the hydrogen ion concentration.

pH Adjust - A means of maintaining the optimum pH through the use of chemical additives.

Phosphate Coating - The process of forming a conversion coat usually on steel by immersing or spraying a hot solution of iron or zinc phosphate.

Pick Up Roll - A roll which revolves within a pan and is partially submerged in the liquid being applied and transfers it to the transfer or applicary roll.

Pollutant - The term "pollutant" means dredged spoil, solid wastes, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal and agricultural waste discharged into water.

Pollutant Parameters - The characteristics or constituents of a waste stream which may alter the chemical, physical, biological, radiological integrity of water.

Polyelectrolytes - Used as a coagulant or a coagulant aid in water and wastewater treatment. They are synthetic or natural polymers containing ionic constituents. They may be cationic, anionic, or nonionic.

POTW - Publicly Owned Treatment Works.

Prechlorination - (1) Chlorination of water prior to filtration. (2) Chlorination of sewage prior to treatment.

Precipitate - The solid particles formed from a liquid solution due to the saturation of the solid in the solution having been achieved.

Precipitation, Chemical - Precipitation induced by addition of chemicals.

Pretreatment - Any wastewater treatment process used to reduce pollution load partially before the wastewater is introduced into a main sewer system or delivered to a treatment plant for substantial reduction of the pollution load.

Printing - The technique of rolling a design on a painted strip.

Priority Pollutant - The 129 specific pollutants established by the EPA from the 65 pollutants and classes of pollutants as outlined in the consent decree of June 8, 1976.

Processed Area - (Expressed in terms of square meters). The area of the coil actually processed. Both sides of the coil are included.

Process Water - Any water which during manufacturing or processing, comes into direct contact with or results from the production or use of any raw materials, intermediate product, finished product, by-product, or waste product.

Production Area - The area of one side of the coil.

PSES - Pretreatment standards for existing sources of indirect discharges under Section 307(b) of the Act.

Publicly Owned Treatment Works - A central treatment works serving a municipality.

Raw Wastewater - Plant water prior to any treatment or use.

RCRA - Resource conservation and Recovery Act (PL 94-580) of 1976, Amendments to Solid Waste Disposal Act.

Recirculated Water - Process water which is returned as process water in the same or in a different process step.

Recoiler - Apparatus to recoil the strip after it is processed.

Rectangular Weir - A weir having a notch that is rectangular in shape.

Recycled Water - Process water which is returned to the same process after treatment.

Reduction Practices - (1) Wastewater reduction practices can mean the reduction of water use to lower the volume of wastewater requiring treatment and (2) the use of chemical reduction to lower the valance state of a specific wastewater pollutant.

Reduction - The opposite of oxidation treatment wherein a reductant (chemical) is used to lower the valence state of a pollutant to a less toxic form e.g., the use of SO_2 to "reduce" hexavalent chromium to trivalent chromium in an acidic solution.

Retention Time - The retention time is equal to the volume of a tank divided by the flow rate of liquids into or out of the tank.

Reverse Roll Coating - Coating with the coating roll revolving in a direction opposite to that of the strip.

Rinse - Water for removal of dragout by dipping, spraying, fogging, etc.

Roll Coating A coat to a coil using rollers.

Sanitary Sewer - A sewer that carries water or wastewater from residences, commercial buildings, industrial plants, and institutions together with minor quantities of ground, storm, and surface waters that are not admitted intentionally.

Sealing Rinse - The final rinse in the conversion coating process which contains a slight concentration of chromic acid.

Secondary Waste Water Treatment - The treatment of wastewater by biological methods after primary treatment by sedimentation.

Sedimentation - Settling by gravity of matter suspended in water.

Settleable Solids - (1) That matter in wastewater which will not stay in suspension during a preselected settling period, such as one hour, but either settles to the bottom or floats to the top. (2) In the Imhoff cone test, the volume of matter that settles to the bottom of the cone in one hour.

Skimmer - A device to remove floating matter from wastewaters.

Sludge - The solids (and accompanying water and organic matter) which are separated from sewage or industrial wastewater.

Sludge Dewatering - A process used to increase the solids concentration of sludge.

Sludge Disposal - The final disposal of solid wastes.

Solvent - A liquid capable of dissolving or dispersing one or more other substances.

Spills - A chemical or material spill is an unintentional discharge of more than 10 percent of the daily usage of a regularly used substance. In the case of a rarely used (one per year or less) chemical or substance, a spill is that amount that would result in 10% added loading to the normal air, water or solids waste loadings measured as the closest equivalent pollutant.

Squeegee - Device used between stages to wipe off excess material applied to the coil to reduce dragout from one process tank to following process tanks.

Steel Basis Material - Means cold rolled steel, hot rolled steel, and chrome, nickel and tin coated steel which are processed.

Stitcher - A machine used to join rolls together to form a continuous strip for coating.

Suspended Solids - (1) Solids that either float on the surface of, or are in suspension in water, wastewater, or other liquids, and which are largely removable by laboratory filtering. (2) The quantity of material removed from wastewater in a laboratory test, as prescribed in "Standard Methods for the Examination of Water and Waste Water" and referred to as non-filterable residue.

Teratogenic - Referring to the ability of a substance to form developmental malformations and monstrosities.

Top Coat - The final applied coating, usually a clear organic film applied over a two coat, two color printed pattern system such as wood graining.

Total Cyanide - The total content of cyanide including simple and/or complex ions. In analytical terminology, total cyanide is the sum of cyanide amenable to chlorination and that which is not according to standard analytical methods.

Total Solids - The total amount of solids in a wastewater in solution and suspension.

Toxicity - Referring to the ability of a substance to cause injury to an organism through chemical activity.

Transfer Roll - The roll between the pick-up and applicator roll which transfers the liquid to the applicator roll.

Treatment Facility Effluent - Treated process wastewater before discharge.

Turbidity - (1) A condition in water or wastewater caused by the presence of suspended matter, resulting in the scattering and absorption of light rays. (2) A measure of fine suspended matter in liquids. (3) An analytical quantity usually reported in arbitrary turbidity units determined by measurements of light diffraction.

Uncoiler - An apparatus at the beginning of the line to pay off the strip and control tension.

Viscosity - That property of a liquid paint or coating material which describes its ability to resist flow or mixing. Paint viscosity is controlled by solvent additions and its control is essential to effective roller-coater operation and uniform dry films thickness.

Water Balance - An accounting of all water entering and leaving a unit process or operation in either a liquid or vapor form or via raw material, intermediate product, finished product, by-product, waste product, or via process leaks, so that the difference in flow between all entering and leaving streams is zero.

Water Use - The quantity of process water used in processing a specified area of coil (expressed as l/sq m of processed area).

Weir - (1) A diversion dam. (2) A device that has a crest and some containment of known geometric shape, such as a V, trapezoid, or rectangle and is used to measure flow of liquid. The liquid surface is exposed to the atmosphere. Flow is related to upstream height of water above the crest, to position of crest with respect to downstream water surface, and to geometry of the weir opening.

METRIC UNITS

CONVERSION TABLE

MULTIPLY (ENGLISH UNITS) by TO OBTAIN (METRIC UNITS)

ENGLISH UNIT	ABBREVIATION	CONVERSION	ABBREVIATION	METRIC UNIT
acre	ac	0.405	ha	hectares
acre - feet	ac ft	1233.5	cu m	cubic meters
British Thermal Unit	BTU	0.252	kg cal	kilogram - calories
British Thermal Unit/pound	BTU/lb	0.555	kg cal/kg	kilogram calories/kilogra
cubic feet/minute	cfm	0.028	cu m/min	cubic meters/minute
cubic feet/second	cfs	1.7	cu m/min	cubic meters/minute
cubic feet	cu ft	0.028	cu m	cubic meters
cubic feet	cu ft	28.32	l	liters
cubic inches	cu in	16.39	cu cm	cubic centimeters
degree Fahrenheit	[F	0.555([F-32)*	[C	degree Centigrade
feet	ft	0.3048	m	meters
gallon	gal	3.785	l	liters
gallon/minute	gpm	0.0631	l/sec	liters/second
horsepower	hp	0.7457	kw	killowatts
inches	in	2.54	cm	centimeters
inches of mercury	in Hg	0.03342	atm	atmospheres
pounds	lb	0.454	kg	kilograms
million gallons/day	mgd	3,785	cu m/day	cubic meters/day
mile	mi	1.609	km	kilometer
pound/square inch (gauge)	psig	(0.06805 psig +1)*	atm	atmospheres (absolute)
square feet	sq ft	0.0929	sq m	square meters
square inches	sq in	6.452	sq cm	square centimeters
ton (short)	ton	0.907	kkg	metric ton (1000 kilogram
yard	yd	0.9144	m	meter

* Actual conversion, not a multiplier

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